

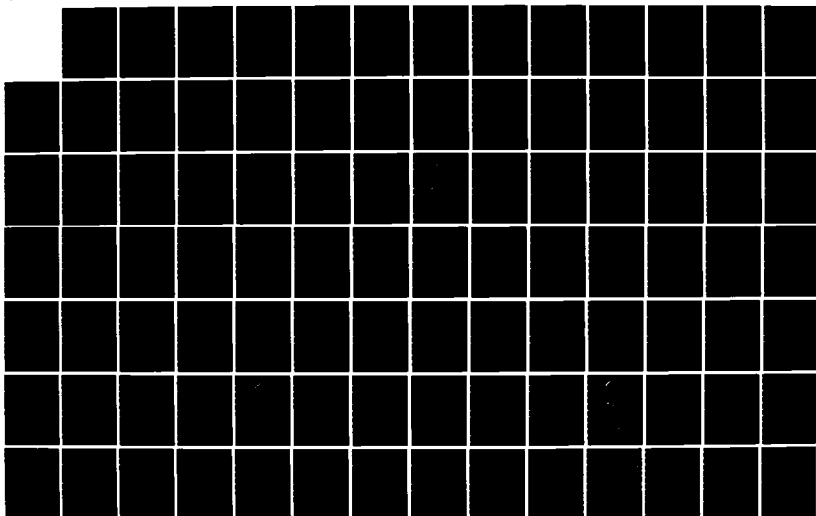
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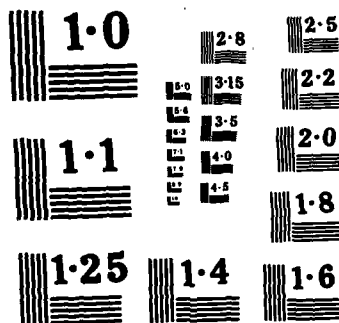
FURTHER GROUND-BASED STUDIES OF SOURCES FROM THE AFGL  
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AFGL-TR-84-0114

FURTHER GROUND-BASED STUDIES OF SOURCES  
FROM THE AFGL INFRARED SKY SURVEY

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J.M. Rodriguez-Espinosa

Center for Astrophysics & Space Sciences, C-011  
University of California, San Diego  
La Jolla, California 92093

Final Report  
March 1980 - December 1983

March 1984

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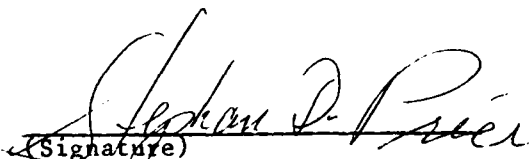
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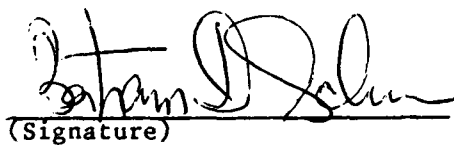
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19. ABSTRACT (Continue on reverse if necessary and identify by block number) Sixteen bright infrared celestial sources were monitored from the ground over a 3 year timespan with broadband filters from 1.2 to 18 microns. Higher resolution narrow-band spectra were also obtained for 3 of the sixteen objects, principally in the 8 to 14 micron region. The combination of variability timescales and spectra permit rough identification of the object class for individual objects. -> cont. keywords include: ---			
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Further Ground-Based Studies of Sources from  
-----  
the AFGL Infrared Sky Survey  
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FINAL REPORT      Contract No. F19628-80-C-0063  
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Introduction  
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Monitoring of the flux levels of a selection of sources in the 1.2 to 20 micron wavelength interval has been done using the 1.5m telescope at Mt. Lemmon operated by UCSD and the University of Minnesota. The time period covered by this contract is from Feb 1, 1980 to Jan 31, 1983, with a subsequent no cost extension to Oct 31, 1983. The principal personnel who have participated in the program are B. Jones, S. P. Willner, R. J. Rudy, and J. M. Rodriguez-Espinosa.

Dates for which observing was scheduled and for which observers were at the telescope are listed in Table 1. Observing time is scheduled in 7 day blocks. Due to inevitable problems with weather and occasionally with instrumentation data was not acquired on 100% of these observing runs, however an average of more than 90% were successful. No observing was attempted during the 2 month Arizona summer monsoon season during which the telescope is routinely shut-down.

Instrumentation initially planned for use in this project was the Ge:Ga bolometer operated at 1.5K. A problem developed with this system in early 1980 and an alternate dewar was used with an Si:As photoconductive detector. The bolometer was put back into use in October 81, and used to the end of the program. Minor differences exist in the filters and spectral response of the 2 detectors, the observations are tabulated separately, and marked distinctly when plotted on the same light curves.

Selection of Objects  
-----

The objects selected fall into three main categories;

- long period variables (Miras),
- stars with dust shells, either oxygen or carbon rich,
- very red objects, not yet classified.

A total of 16 objects were selected for detailed study. An attempt was made to select objects around the sky to provide an even observing load throughout the year. A list of objects with their classification (when known), periods, and coordinates, is provided in Table 2.

## The Observations

---

Table 3 summarizes all observations of the program objects with brightnesses given in magnitudes. The uncertainties are  $\pm 0.1$  mag except at 18 microns where the uncertainty is  $\pm 0.2$  mag.

Figure 1 presents the light curves of each object at each wavelength. For objects having a well established period the data has been plotted as a function of the visual phase. Objects without a known periodicity are plotted against time in Julian days. We include for completeness the AAVSO V band light curves.

Figure 2 shows the spectra obtained at Mt. Lemmon for this program. Where spectra are available from other sources they are referenced.

We present below a brief discussion of characteristics of each of the sources, taken both from our data and from the general literature.

### R And (GL 0059)

---

This star has been classified as S4.7e, a Mira type variable with a period of 409.2 days. The range of variability in the V band is from +6 to +14 mag, with some differences in brightness between successive cycles. There is clearly an excess emission in the spectrum at 10 microns. The IR maximum occurs at visual phase 0.3 for all the IR bands measured. Spectra were taken both at 2-4 microns and 8-13 microns. The increase in flux at around 10.5 microns shows the object has a silicon carbide component in its dust shell, and is therefore carbon rich.

### HV Cas (GL 0167, IRC +50030)

---

HV Cas is classified as Ne, a Mira type variable with a period of 567 days. It is carbon rich showing excess flux longward of 10 microns typical of silicon-carbide dust. It also shows a feature at 2.3 microns from CO, and features at 3.07 and 3.9 microns. Our data are hard to interpret showing a possible minimum in flux at phase 0.25 with a rise at all IR wavelengths from phase 0.25 to 0.85 at which point there is a maximum. The latest phase measured 0.94 is significantly lower than the data at 0.85, but clearly more data would be a help here.

### TX Cam (GL 0664, IRC 60150)

---

TX Cam is an MB, oxygen rich Mira type variable with a period of 557.4 days. It shows 10 micron silicate emission. The light curve published by the AAVSO shows considerable irregularity, our data show that these irregular fluctuations tend to occur simultaneously through the spectrum into the IR.

NV Aur (GL 0700, IRC +50137)

-----

NV Aur is an oxygen rich late type M star, showing 1.9 and 2.7 micron water absorption bands and silicate emission with a possible self absorbed center at 10 microns (Merrill & Stein, 1976 II). Our data do not allow determination of the period but clear variability is seen, with some evidence that an increase in temperature from 900K to 1000K causes at least part of the increase in luminosity.

GL 0809

-----

This source is in a blank field on the Palomar sky survey plates. It shows a 3.1 micron absorption and a smooth featureless continuum in the 8-13 micron range. It is probably a highly reddened carbon Mira. We were not able to acquire adequate data on it to predict a period.

R Lyn (GL 1050)

-----

R Lyn is classified as S 2.5,5e - S6,8e, a Mira type variable with a period of 378.7 days.

R Gem

-----

R Gem is classified as S3,9e to S 6,9e. It is a Mira type variable with a period of 369.6 days. A spectrum from 8-13 microns is presented in figure 2. This shows a small silicate emission superimposed on a 2500K blackbody continuum. As with R Leo the period is close to the length of the year restricting our coverage of the IR light curve.

R L Mi (GL 1376)

-----

R L Mi is classified as M7e to M8e, a mira type variable with a period of 372.3 days. The 10 micron spectrum shows silicate emission (Forrest et al. 1975). Our data shows the temperature to be considerably hotter at phase 0.1 (2400K) than at phase 0.7 (1750K).

R Leo (GL 1380)

-----

R Leo is classified as M6e to M9e, a Mira type variable with a period of 312.6 days. There is some irregularity in the visual light curve from cycle to cycle (AAVSO). It shows a small 10 micron excess due to silicate emission and 2.3 and 2.7 micron absorptions due to CO and water respectively (Merrill & Stein 1976 I). Because the period quite closely matches the length of the year we do not have good coverage of the complete cycle. From our data there is some evidence of temperature changes

CW Leo (GL 1381, IRC +10216)

-----

CW Leo is better known as IRC +10216. The IR spectrum shows silicon carbide in emission and the usual C star feature at 3.07 microns. Our data does not give evidence for periodicity or for large temperature changes associated with the variability.



SS Vir (GL 1549)

-----

SS Vir is classified as C6.3, a Mira type variable with a period of 354.7 days. It's 2-4 micron spectrum shows absorptions at 3.07 and 3.9 microns characteristic of carbon stars. The 8-13 micron spectrum is presented in figure 2. This shows the silicon carbide emission feature as expected. The maximum emission in the IR occurs at visual phase of 0.3-0.4 and corresponds to an increase in the temperature from our observed minimum of 1900K to a peak of 2250K.

GL 2290

-----

GL 2290 shows an optically thick dust shell with a temperature of about 600K, and a silicate absorption feature at 10 microns (spectrum shown in figure 2). The source has brightened considerably without any sign of periodic behavior during our monitoring period.

Xi Cyg (GL 2465)

-----

Xi Cyg is classified as S7.1e to S10.1e, a Mira type variable with a period of 406.7 days. It shows a large silicate emission at 10 microns, there is no evidence for a change in temperature during the cycle.

GL 2704 (IRC 50357)

-----

GL 2704 shows the features at 3.07 microns in absorption and 10.5 microns in emission typical of a carbon star. It shows variability of slightly more than a magnitude in the IR with some evidence for changes in temperature from a minimum of 750K to a maximum observed of 950K. We do not have adequate data to see whether there is evidence of periodicity.

GL 2885

-----

This source shows a silicate absorption feature at 10 microns, and a combined water and CO absorption at 2.7 microns (Merrill & Stein, 1976 III). Probably the source is a late M star, oxygen rich, with an extensive cool dust shell. Our data suggests that any periodicity must be on a time scale of 600 days or more. No significant change in temperature of the dust shell can be seen during changes of more than a magnitude in the mid-IR flux.

GL 3068

-----

GL 3068 shows a very cool continuum ( $T=325K$ ) with a 3.1 micron carbon star absorption feature, and a feature at 11 microns probably due to silicon carbide in absorption (Jones et al. 1978). Our data show significant variability 1 mag at 3.5 microns, 0.5 mag at 10 microns. No change in temperature is seen. It is not possible to deduce a period from this data.

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Table 1

Telescope Time Scheduled for this Program

Dates	Instrument	Observers	Comments
4/80	Si: As	SPW	Partly clear
5/80	Si: As	RJR	Partly clear
6/80	Si: As	SPW	Partly clear
9/80	Si: As	SPW	Good weather
11/80	Si: As	BJ	Partly clear
1/81	Si: As	JMRE	Good weather
2/81	Si: As	BJ	Good weather
5/81	Si: As	RJR	Good weather
6/81	Si: As	JMRE	Good weather
7/81	Si: As	JMRE	100% cloudy
9/81	Bolometer	JMRE	100% cloudy
10/81	Bolometer	JMRE	Good weather
12/81	Bolometer	JMRE	Mostly cloudy
2/82	Bolometer	JMRE	Good weather
3/82	Bolometer	JMRE	Good weather
5/82	Bolometer	JMRE	Good weather
6/82	Bolometer	JMRE	Good weather
7/82	Bolometer	BJ	Good weather
9/82	Bolometer	BJ	Good weather
11/82	Bolometer	JMRE	Good weather
12/82	Bolometer	BJ	Good weather
1/83	Bolometer	JMRE	Good weather
2/83	Bolometer	BJ	100% cloudy
3/83	Bolometer	JMRE	Partly cloudy
4/83	Bolometer	BJ	Partly cloudy
5/83	Bolometer	JMRE	Good weather
6/83	Bolometer	JMRE	Partly cloudy

Observers

BJ Barbara Jones  
 JMRE Jose Rodriguez-Espinosa  
 RJR Richard Rudy  
 SPW Steve Willner

Table 2

Program Objects

Name	Classification	RA(1950)	DEC(1950)	Period
And GL 0059	S4.7e C rich M	00h 21m 23s	+38 18 02	409.2d
Cas GL 0167	Ne M	01h 08m 04s	+53 28 00	527d
Cam GL 0664	MB M	04h 56m 44s	+56 06 54	557.4d
Aur GL 0700	O rich	05h 07m 20s	+52 48 48	?
GL 0809	C rich	05h 40m 33s	+32 40 58	?
Lyn GL 1050	S2.5, 5e M	06h 57m 14s	+55 24 24	378.86d
Gem	S3.9e O rich M	07h 04m 19s	+22 46 30	369.63d
Mi GL 1376	M7e-M8e M	09h 42m 35s	+34 44 18	372.3d
Leo GL 1380	M6e-M9e M	09h 44m 52s	+11 39 48	312.6d
Leo GL 1381#	C star	09h 45m 18s	+13 30 36	?
Vir GL 1549	C6.3 M	12h 22m 41s	+01 02 46	354.7d *
GL 2290	O rich	18h 56m 04s	+06 38 52	?
Cyg GL 2465	S7.1e O rich M	19h 48m 38s	+32 47 10	406.8d *
GL 2704	C rich	21h 03m 34s	+51 36 48	?
GL 2885	O rich	22h 17m 41s	+59 35 24	?
GL 3068	Cx?	23h 16m 41s	+16 54 36	?

Notes

- \* period irregular
- ? period unknown
- # known as IRC +10216
- M Mira type variable
- Cx? Probably carbon star embedded in dust shell

TABLE 3

# R AND

ATES	PHASE	1.2	1.6	2.2	2.3	3.5	3.6	4.9
11/80	0.17	*****	-0.02	*****	-0.28	-0.99	*****	-1.34
22/80	0.20	*****	-0.08	*****	-0.37	-1.13	*****	-1.39
19/80	0.42	*****	-0.08	*****	-0.53	-1.23	*****	-1.45
22/80	0.57	*****	0.31	*****	-0.16	-0.90	*****	-1.18
22/81	0.72	*****	0.89	*****	0.28	-0.47	*****	-0.76
22/81	0.02	*****	0.83	*****	0.42	-0.42	*****	-0.76
17/81	0.08	*****	0.66	*****	0.21	-0.59	*****	-1.01
20/81	0.31	*****	-0.27	-0.54	*****	*****	-1.19	-1.33
20/81	0.38	*****	-0.09	-0.58	*****	*****	-1.30	-1.51
3/82	0.01	1.53	0.75	0.32	*****	*****	-0.41	-0.76
24/82	0.22	1.03	0.19	-0.28	*****	*****	-1.07	-1.45
13/82	0.41	0.74	-0.23	-0.71	*****	*****	-1.32	-1.45
29/83	0.82	3.65	1.38	0.80	*****	*****	0.19	0.11

# R AND

ATES	PHASE	8.4	8.6	10.3	10.6	11.3	12.8	18.0
11/80	0.17	-2.43	*****	*****	-3.12	*****	-3.26	*****
22/80	0.20	-2.45	*****	*****	-3.10	*****	-3.23	*****
19/80	0.42	-2.37	*****	*****	-3.06	*****	-3.25	*****
22/80	0.57	-2.10	*****	*****	-2.81	*****	-3.00	*****
22/81	0.72	-1.70	*****	*****	-2.40	*****	-2.65	*****
22/81	0.02	-1.91	*****	*****	-2.76	*****	-2.92	*****
17/81	0.08	-2.06	*****	*****	-2.86	*****	-3.07	*****
20/81	0.31	*****	-2.41	-3.18	*****	-2.75	-3.27	-3.58
20/81	0.38	*****	-2.49	-3.25	*****	-3.36	-3.40	-3.80
3/82	0.01	*****	-1.90	-2.67	*****	-2.73	-2.66	-2.63
24/82	0.22	*****	-2.50	-3.28	*****	-3.34	-3.46	-3.56
13/82	0.41	*****	-2.60	-3.35	*****	-3.34	-3.32	-3.74
29/83	0.82	*****	-1.16	-2.00	*****	-2.11	-2.22	-0.86

## GL 2885

TES	DAYS	1.2	1.6	2.2	2.3	3.5	3.6	4.9
2/80	0	*****	*****	*****	6.26	1.96	*****	0.45
1/80	90	*****	*****	*****	5.22	1.20	*****	-0.25
2/80	153	*****	*****	*****	4.90	1.16	*****	0.40
2/81	334	*****	*****	*****	4.39	0.74	*****	-0.49
7/81	360	*****	*****	*****	4.39	0.81	*****	-0.65
10/81	485	*****	8.24	4.62	*****	*****	0.79	-0.65
10/82	687	8.75	8.51	5.21	*****	*****	1.40	-0.07
5/82	723	9.38	9.21	5.29	*****	*****	1.45	0.07
2/82	740	*****	*****	5.04	*****	*****	1.22	-0.12
29/82	830	*****	8.19	5.69	*****	*****	1.82	0.34
29/83	1071	*****	*****	7.27	*****	*****	2.60	1.24

## GL 2885

ATES	DAYS	8.4	8.6	10.3	10.6	11.3	12.8	18.0
22/80	0	-1.19	*****	*****	-0.75	*****	-2.18	*****
21/80	90	-1.77	*****	*****	-1.47	*****	-2.69	*****
22/80	153	-1.92	*****	*****	-1.65	*****	-2.84	*****
22/81	334	-2.10	*****	*****	-2.00	*****	-3.04	*****
17/81	360	-2.13	*****	*****	-1.95	*****	-3.08	*****
20/81	485	*****	-2.01	-1.45	*****	-2.36	-3.19	-4.16
10/82	687	*****	-1.65	-1.26	*****	-2.43	-3.02	-3.20
15/82	723	*****	-1.63	-1.01	*****	-1.94	-2.73	-3.91
2/82	740	*****	-1.63	-1.07	*****	-1.88	-2.84	-3.32
29/82	830	*****	-1.19	-0.54	*****	-1.49	-2.60	-3.24
29/83	1071	*****	-0.28	0.31	*****	-0.90	-1.90	-1.18

## GL 2704

ES	DAYS	1.2	1.6	2.2	2.3	3.5	3.6	4.9
1/80	0	*****	*****	*****	3.30	0.88	*****	-0.19
1/80	92	*****	4.58	*****	2.45	0.15	*****	-0.84
2/81	335	*****	6.00	*****	3.57	1.18	*****	0.01
7/81	361	*****	*****	*****	3.64	1.37	*****	0.08
1/81	457	*****	4.89	3.60	*****	*****	1.73	0.13
7/81	485	*****	4.64	2.68	*****	*****	0.25	-0.86
9/82	688	6.71	4.38	2.64	*****	*****	0.39	-0.72
7/82	712	6.60	4.57	2.70	*****	*****	0.44	-0.58
7/82	741	*****	4.38	2.53	*****	*****	0.24	-0.74
7/82	831	7.29	5.70	3.65	*****	*****	1.19	0.03
3/83	1071	8.26	5.34	3.37	*****	*****	0.91	-0.23

## GL 2704

ES	DAYS	8.4	8.6	10.3	10.6	11.3	12.8	18.0
1/80	0	-1.51	*****	*****	-1.83	*****	-1.89	*****
1/80	92	-1.91	*****	*****	-2.18	*****	-2.34	*****
2/81	335	-1.23	*****	*****	-1.61	*****	-1.70	*****
7/81	361	-1.24	*****	*****	-1.50	*****	-1.70	*****
1/81	457	*****	-1.24	-1.52	*****	-1.54	-2.11	-2.43
7/81	485	*****	-2.23	-2.12	*****	-2.21	-2.80	-3.15
9/82	688	*****	-1.88	-2.19	*****	-2.82	-2.54	-2.88
7/82	712	*****	-1.82	-1.97	*****	-1.23	-2.29	-2.20
7/82	741	*****	-1.81	-2.01	*****	-2.23	-2.34	-2.18
7/82	831	*****	-1.30	-1.50	*****	-1.92	-1.81	-1.83
3/83	1071	*****	-1.51	-1.72	*****	-1.97	-1.93	-1.19



# X CYG

ATES	PHASE	1.2	1.6	2.2	2.3	3.5	3.6	4.9
16/80	0.50	*****	*****	*****	-2.25	-2.83	*****	-2.89
11/80	0.64	*****	-1.37	*****	-1.84	-2.58	*****	-2.67
21/80	0.89	*****	-1.46	*****	-1.98	-2.76	*****	-2.98
24/81	0.28	*****	-2.14	*****	-2.53	-3.14	*****	-3.19
22/81	0.49	*****	-1.85	*****	-2.35	-3.04	*****	-3.13
17/81	0.55	*****	-1.62	*****	-2.20	-2.86	*****	-3.04
10/82	0.36	-0.87	-2.02	-2.50	*****	*****	-3.19	-3.25
3/82	0.42	-0.83	-1.74	-2.30	*****	*****	-3.01	-3.13
3/82	0.49	-0.72	-1.65	-2.24	*****	*****	-2.98	-3.10
29/82	0.71	0.12	-0.91	-1.53	*****	*****	-2.34	-2.58
28/83	0.30	-0.55	-1.87	-2.37	*****	*****	-2.95	-3.04

# X CYG

DATES	PHASE	8.4	8.6	10.3	10.6	11.3	12.8	18.0
/16/80	0.50	*****	*****	*****	*****	*****	*****	*****
/11/80	0.64	-3.24	*****	*****	-3.79	*****	-4.11	*****
/21/80	0.89	-3.45	*****	*****	-4.01	*****	-4.16	*****
/24/81	0.28	-4.08	*****	*****	-4.27	*****	-4.47	*****
/22/81	0.49	-3.52	*****	*****	-4.13	*****	-4.26	*****
/17/81	0.55	-3.48	*****	*****	-4.01	*****	-4.23	*****
/10/82	0.36	*****	-3.81	-4.43	*****	*****	-4.51	-3.22
/3/82	0.42	*****	-3.71	-4.37	*****	*****	-4.42	-4.24
/3/82	0.49	*****	-3.65	-4.23	*****	*****	-4.22	-4.18
/29/82	0.71	*****	-3.26	-3.75	*****	-3.84	-3.94	-4.09
/28/83	0.30	*****	-3.52	-4.26	*****	-4.33	-4.24	-3.53

## GL 2290

DATES	DAYS	1.2	1.6	2.2	2.3	3.5	3.6	4.9
21/80	0	*****	*****	*****	4.96	1.09	*****	-0.28
21/80	92	*****	*****	*****	4.01	0.49	*****	-0.80
24/81	248	*****	*****	*****	3.48	0.28	*****	-1.11
22/81	335	*****	*****	*****	3.38	0.09	*****	-1.04
17/81	361	*****	6.68	*****	3.34	0.16	*****	-1.21
10/82	688	7.96	7.26	4.25	*****	*****	0.83	-0.47
3/82	712	8.15	7.62	4.37	*****	*****	1.04	-0.34
2/82	741	*****	*****	4.12	*****	*****	0.74	-0.07
29/82	831	*****	7.80	4.60	*****	*****	1.15	-0.22
28/83	1071	*****	*****	6.02	*****	*****	2.08	0.65
0/83	1073	*****	*****	5.94	*****	*****	2.02	0.67

## GL 2290

DATES	DAYS	8.4	8.6	10.3	10.6	11.3	12.8	18.0
21/80	0	-2.06	*****	*****	-2.07	*****	-3.03	*****
21/80	92	-2.56	*****	*****	-2.59	*****	-3.34	*****
24/81	248	-2.79	*****	*****	-2.97	*****	-3.71	*****
22/81	335	-2.85	*****	*****	-3.06	*****	-3.70	*****
17/81	361	-2.88	*****	*****	-3.03	*****	-3.76	*****
10/82	688	*****	-2.30	-2.24	*****	*****	-3.38	-2.86
3/82	712	*****	-2.25	-2.31	*****	*****	-3.26	-4.04
2/82	741	-2.38	*****	-2.25	*****	*****	-3.42	-4.29
29/82	831	*****	-2.16	-1.96	*****	-2.71	-3.36	-3.79
28/83	1071	*****	-1.20	-1.00	*****	-1.75	-2.42	-2.34
0/83	1073	*****	-1.35	-0.99	*****	-1.93	-2.67	-3.40

## SS VIR

DATES	PHASE	1.2	1.6	2.2	2.3	3.5	3.6	4.9
6/11/80	0.54	*****	1.86	*****	0.97	0.13	*****	0.12
1/21/81	0.17	*****	1.50	*****	0.79	0.08	*****	-0.16
2/24/81	0.27	*****	1.35	*****	0.58	-0.01	*****	-0.14
6/17/81	0.58	*****	1.89	*****	0.91	0.08	*****	0.26
2/4/82	0.24	*****	1.25	0.51	*****	*****	-0.05	*****
3/5/82	0.32	2.29	1.22	0.50	*****	*****	-0.09	-0.13
6/4/82	0.58	3.29	2.21	1.22	*****	*****	0.34	0.34
12/13/82	0.12	2.47	1.44	0.69	*****	*****	0.18	-0.04
01/22/83	0.23	2.37	1.31	0.65	*****	*****	-0.02	-0.17

## SS VIR

DATES	PHASE	8.4	8.6	10.3	10.6	11.3	12.8	18.0
6/11/80	0.54	-0.64	*****	*****	-1.00	*****	-0.93	*****
1/21/81	0.17	-0.76	*****	*****	-1.16	*****	-1.17	*****
2/24/81	0.27	-0.80	*****	*****	-1.13	*****	-1.20	*****
6/17/81	0.58	-0.62	*****	*****	-0.99	*****	-0.95	*****
2/4/82	0.24	*****	-0.97	-1.05	*****	*****	-1.05	-0.81
3/5/82	0.32	*****	-0.90	-1.06	*****	-1.40	-1.10	-1.60
6/4/82	0.58	*****	-0.49	-0.72	*****	-1.02	-0.51	-1.05
12/13/82	0.12	*****	-0.82	-0.86	*****	-1.28	-0.92	-1.31
01/22/83	0.23	*****	-0.54	-1.07	*****	-1.54	-1.06	-1.45

CW LEO

DATES	DAYS	1.2	1.6	2.2	2.3	3.5	3.6	4.9
5/11/80	0	*****	*****	*****	*****	-3.23	*****	-4.96
2/25/81	290	*****	5.76	*****	2.39	-1.86	*****	-3.98
2/4/82	634	*****	4.01	1.11	*****	*****	-4.10	-4.90
3/5/82	663	*****	4.11	1.05	*****	*****	-3.00	-4.78
5/9/82	728	7.97	4.57	1.58	*****	*****	-2.71	-4.49
12/13/82	946	*****	5.28	2.28	*****	*****	-2.08	-4.01
01/22/83	985	7.66	4.95	1.94	*****	*****	-2.37	-4.26
05/30/83	1110	6.29	3.74	0.68	*****	*****	-3.28	-4.84

CW LEO

DATES	DAYS	8.4	8.6	10.3	10.6	11.3	12.8	18.0
5/11/80	0	-7.31	*****	*****	-7.69	*****	*****	*****
2/25/81	290	-6.37	*****	*****	-6.91	*****	-7.25	*****
2/4/82	634	*****	-7.18	-7.62	*****	-7.94	-7.84	*****
3/5/82	663	*****	-7.15	-7.53	*****	-7.80	-7.85	-8.41
5/9/82	728	*****	-6.95	-7.44	*****	-7.69	-7.91	-8.11
12/13/82	946	*****	-6.61	-6.86	*****	-7.27	-7.23	-8.05
01/22/83	985	*****	-6.79	-7.17	*****	-7.44	-7.53	-7.96
05/30/83	1110	*****	-7.26	-7.52	*****	-8.11	-8.05	-7.42

# R LEO

DATES	PHASE	1.2	1.6	2.2	2.3	3.5	3.6	4.9
5/11/80	0.49	*****	*****	*****	-2.07	-2.81	*****	-3.00
6/11/80	0.59	*****	-1.78	*****	-2.21	-2.84	*****	-3.04
1/21/81	0.31	*****	-1.87	*****	-2.40	-3.06	*****	-3.31
2/25/81	0.42	*****	-1.68	*****	-2.19	-2.98	*****	-3.23
3/7/82	0.62	-1.37	-2.07	-2.43	*****	*****	-3.09	-3.38
5/10/82	0.83	-1.45	-2.23	-2.59	*****	*****	-3.20	-3.44
11/06/82	0.40	-0.82	-1.71	-2.18	*****	*****	-2.89	-3.15
01/22/83	0.65	-0.98	-1.91	-2.29	*****	*****	-2.99	-3.15
05/30/83	0.06	-1.45	-2.33	-2.77	*****	*****	-3.19	-3.24

# R LEO

DATES	PHASE	8.4	8.6	10.3	10.6	11.3	12.8	18.0
5/11/80	0.49	-3.79	*****	*****	-4.15	*****	-4.51	*****
6/11/80	0.59	-3.68	*****	*****	-4.19	*****	-4.65	*****
1/21/81	0.31	-3.63	*****	*****	-4.19	*****	-4.54	*****
2/25/81	0.42	-3.66	*****	*****	-4.13	*****	-4.43	*****
3/7/82	0.62	*****	-4.01	-4.40	*****	-4.34	-4.62	-4.85
5/10/82	0.83	*****	-4.07	-4.50	*****	-4.70	-4.64	-4.88
11/06/82	0.40	*****	-3.72	-4.09	*****	-4.25	-4.44	-4.77
01/22/83	0.65	*****	-3.79	-4.23	*****	-3.98	-4.51	-4.45
05/30/83	0.06	*****	-3.97	-4.25	*****	-4.59	-4.69	-3.88

# R L MI

DATES	PHASE	1.2	1.6	2.2	2.3	3.5	3.6	4.9
6/11/80	0.11	*****	-0.55	*****	-0.99	-1.47	*****	-1.50
1/21/81	0.71	*****	0.94	*****	0.19	-0.75	*****	-1.16
2/25/81	0.80	*****	0.96	*****	0.29	-0.74	*****	-1.21
2/4/82	0.73	*****	1.81	0.81	*****	*****	-0.38	-0.77
3/5/82	0.81	2.21	1.24	0.49	*****	*****	-0.67	-1.23
11/06/82	0.47	1.48	0.49	0.00	*****	*****	-0.77	-1.00
01/22/83	0.67	1.65	0.62	-0.04	*****	*****	-0.97	-1.28
05/30/83	0.02	0.92	0.05	-0.49	*****	*****	-1.17	-1.22

# R L MI

DATES	PHASE	8.4	8.6	10.3	10.6	11.3	12.8	18.0
6/11/80	0.11	-2.23	*****	*****	-2.87	*****	-3.14	*****
1/21/81	0.71	-1.75	*****	*****	-2.50	*****	-2.76	*****
2/25/81	0.80	-1.83	*****	*****	-2.51	*****	-2.73	*****
2/4/82	0.73	*****	-1.57	-2.19	*****	-2.39	-1.98	-2.78
3/5/82	0.81	*****	-1.91	-2.56	*****	-2.63	-2.60	-2.19
11/06/82	0.47	*****	-1.70	-2.32	*****	-2.45	-2.65	-2.94
01/22/83	0.67	*****	-1.88	-2.49	*****	-2.62	-2.77	-2.99
05/30/83	0.02	*****	-2.11	-2.72	*****	-3.17	-3.15	-2.44

# R GEM

DATES	PHASE	1.2	1.6	2.2	2.3	3.5	3.6	4.9
1/21/81	0.59	*****	2.07	*****	1.73	1.21	*****	1.06
10/19/81	0.32	*****	1.59	1.20	*****	*****	0.68	0.66
2/3/82	0.61	*****	2.78	2.34	*****	*****	1.47	1.40
3/6/82	0.70	3.60	2.56	2.25	*****	*****	1.75	1.50
9/24/82	0.15	3.20	2.24	1.85	*****	*****	1.23	1.38
12/13/82	0.46	2.78	1.91	1.48	*****	*****	0.97	0.96

# R GEM

DATES	PHASE	8.4	8.6	10.3	10.6	11.3	12.8	18.0
1/21/81	0.59	0.50	*****	*****	0.33	*****	*****	*****
10/19/81	0.32	*****	0.11	-0.24	*****	-0.27	-0.63	-0.91
2/3/82	0.61	*****	0.78	0.58	*****	0.39	0.74	*****
3/6/82	0.70	*****	0.86	0.69	*****	0.43	0.23	*****
9/24/82	0.15	*****	0.84	0.58	*****	0.13	0.12	*****
12/13/82	0.46	*****	0.45	0.30	*****	0.12	-0.02	-0.31

# R LYN

DATES	PHASE	1.2	1.6	2.2	2.3	3.5	3.6	4.9
03/05/82	0.61	4.25	3.08	2.58	*****	*****	2.01	1.78
09/24/82	0.15	3.20	2.24	1.85	*****	*****	1.23	1.38
12/12/82	0.35	3.86	2.89	2.29	*****	*****	1.58	1.50
01/22/83	0.46	4.31	3.24	2.59	*****	*****	1.96	1.97

# R LYN

DATES	PHASE	6.4	8.6	10.3	10.6	11.3	12.8	12.0
03/05/82	0.61	*****	1.33	1.13	*****	1.15	0.81	0.65
09/24/82	0.15	*****	0.84	0.58	*****	0.13	0.12	*****
12/12/82	0.35	*****	1.09	0.73	*****	0.34	1.01	*****
01/22/83	0.46	*****	1.42	1.29	*****	1.06	0.94	*****



## GL 809

DATES	DAYS	1.2	1.6	2.2	2.3	3.5	3.6	4.9
2/25/81	0	*****	*****	*****	5.19	2.28	*****	0.76
10/19/81	235	*****	6.17	4.00	*****	*****	1.07	-0.26
2/5/82	345	*****	6.30	4.28	*****	*****	1.23	-0.09
3/6/82	374	*****	6.49	4.50	*****	*****	1.57	0.14
9/26/82	579	*****	8.17	5.67	*****	*****	2.48	0.98
11/05/82	618	*****	8.08	5.66	*****	*****	2.45	1.09

## GL 809

DATES	DAYS	8.4	8.6	10.3	10.6	11.3	12.8	18.0
2/25/81	0	-1.18	*****	*****	-1.56	*****	-1.89	*****
10/19/81	235	-2.07	*****	-2.42	*****	-2.50	-2.73	-3.28
2/5/82	345	*****	-1.92	-2.12	*****	-2.30	-2.51	-2.79
3/6/82	374	*****	-1.80	-1.96	*****	-2.21	-2.31	-2.84
9/26/82	579	*****	-1.15	-1.64	*****	-1.63	-1.93	-1.16
11/05/82	618	*****	-1.10	-1.44	*****	-1.69	-1.90	-2.32

# NV AUR

DATES	DAYS	1.2	1.6	2.2	2.3	3.5	3.6	4.9
9/19/80	0	*****	4.31	*****	2.66	0.76	*****	-0.18
1/22/81	125	*****	*****	*****	3.11	1.06	*****	0.14
2/25/81	159	*****	5.09	*****	3.23	1.14	*****	0.22
10/19/81	395	*****	4.11	2.33	*****	*****	0.25	-0.69
3/7/82	534	6.11	3.77	2.19	*****	*****	0.26	-0.73
9/26/82	738	7.17	4.76	3.05	*****	*****	1.00	0.15
11/05/82	777	7.97	5.60	3.81	*****	*****	1.80	1.01
12/13/82	814	8.40	5.18	3.38	*****	*****	1.38	0.44
01/22/83	855	8.05	5.65	3.53	*****	*****	1.22	0.47

# NV AUR

DATES	DAYS	8.4	8.6	10.3	10.6	11.3	12.8	18.0
9/19/80	0	-1.81	*****	*****	-2.55	*****	-2.73	*****
1/22/81	125	-1.56	*****	*****	-2.31	*****	-2.53	*****
2/25/81	159	-1.43	*****	*****	-2.14	*****	-2.40	*****
10/19/81	395	*****	-2.43	-2.95	*****	-3.17	-3.23	-4.40
3/7/82	534	*****	-2.42	-3.11	*****	-3.28	-3.39	-5.23
9/26/82	738	*****	-1.86	-2.47	*****	-2.58	-2.72	-2.47
11/05/82	777	*****	-0.88	-1.34	*****	-1.65	-1.58	-2.89
12/13/82	814	*****	-1.39	-1.83	*****	-2.19	-2.36	-3.57
01/22/83	855	*****	-1.31	-1.55	*****	-2.08	-2.25	-3.48

## TX CAM

DATES	PHASE	1.2	1.6	2.2	2.3	3.5	3.6	4.9
1/22/81	0.91	*****	0.96	*****	0.03	-1.19	*****	-1.62
2/24/81	0.97	*****	0.78	*****	-0.12	-1.31	*****	-1.78
9/21/81	0.34	*****	0.49	-0.16	*****	*****	-1.17	-1.53
10/19/81	0.39	*****	-0.37	-0.92	*****	*****	-1.76	-2.12
2/4/82	0.59	1.38	0.25	-0.32	*****	*****	-1.25	-1.80
7/6/82	0.64	1.71	0.55	-0.05	*****	*****	-1.07	-1.46
9/24/82	0.00	1.56	0.42	-0.31	*****	*****	-1.40	-1.77
11/05/82	0.08	1.20	0.10	-0.56	*****	*****	-1.59	-2.01
12/13/82	0.15	0.81	-0.26	-0.80	*****	*****	-1.65	-2.01

## TX CAM

DATES	PHASE	8.4	8.6	10.3	10.6	11.3	12.8	18.0
1/22/81	0.91	-2.57	*****	*****	-3.50	*****	-3.52	*****
2/24/81	0.97	-2.64	*****	*****	-3.59	*****	-3.59	*****
9/21/81	0.34	*****	-2.82	-3.74	*****	-3.94	-3.42	-3.51
10/19/81	0.39	*****	-3.37	-4.37	*****	-4.26	-4.08	-5.03
2/4/82	0.59	*****	-2.99	-3.75	*****	-3.89	-3.67	-4.33
7/6/82	0.64	*****	-2.73	-3.51	*****	-3.57	-3.47	-4.02
9/24/82	0.00	*****	-2.95	-3.74	*****	-4.04	-3.63	-4.38
11/05/82	0.08	*****	-3.21	-4.01	*****	-3.12	-3.92	-4.68
12/13/82	0.15	*****	-3.36	-4.23	*****	-4.08	-3.76	-4.95

# HV CAS

DATES	PHASE	1.2	1.6	2.2	2.3	3.5	3.6	4.9
6/22/80	0.94	*****	3.78	*****	2.32	0.76	*****	0.15
9/19/80	0.11	*****	4.48	*****	2.99	1.28	*****	0.58
11/22/80	0.23	*****	4.59	*****	2.90	1.35	*****	0.58
1/21/81	0.35	*****	4.30	*****	2.79	1.22	*****	0.41
2/25/81	0.41	*****	3.99	*****	2.53	1.06	*****	0.38
5/22/81	0.57	*****	3.78	*****	2.33	0.76	*****	0.21
10/19/81	0.86	*****	3.28	2.04	*****	*****	0.57	-0.09
9/26/82	0.86	5.19	3.74	2.47	*****	*****	0.99	0.23
12/13/82	0.65	4.58	3.23	2.13	*****	*****	0.82	0.23

# HV CAS

DATES	PHASE	8.4	8.6	10.3	10.6	11.3	12.8	18.0
6/22/80	0.94	-0.83	*****	*****	-1.01	*****	-1.04	*****
9/19/80	0.11	-0.39	*****	*****	-0.71	*****	-0.76	*****
11/22/80	0.23	-0.38	*****	*****	-0.70	*****	-0.64	*****
1/21/81	0.35	-0.51	*****	*****	-0.79	*****	-0.83	*****
2/25/81	0.41	-0.60	*****	*****	-0.86	*****	-0.84	*****
5/22/81	0.57	-0.71	*****	*****	-1.06	*****	-1.04	*****
10/19/81	0.86	*****	-0.95	-1.20	*****	-1.37	-1.04	-1.39
9/26/82	0.86	*****	-0.75	-1.06	*****	-1.07	-1.16	*****
12/13/82	0.65	*****	-0.50	-0.74	*****	-1.18	-0.81	-0.61

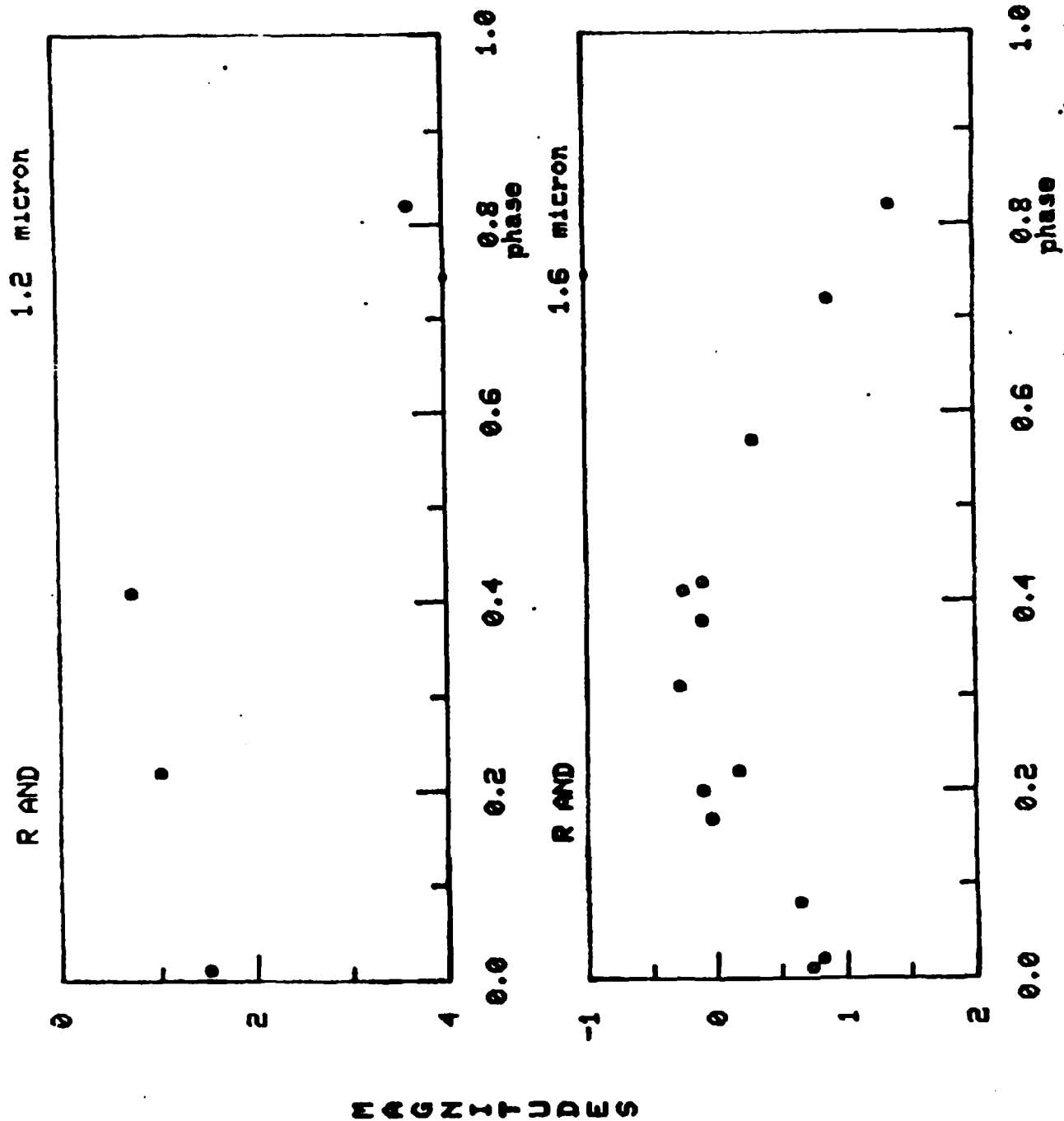
## GL 3068

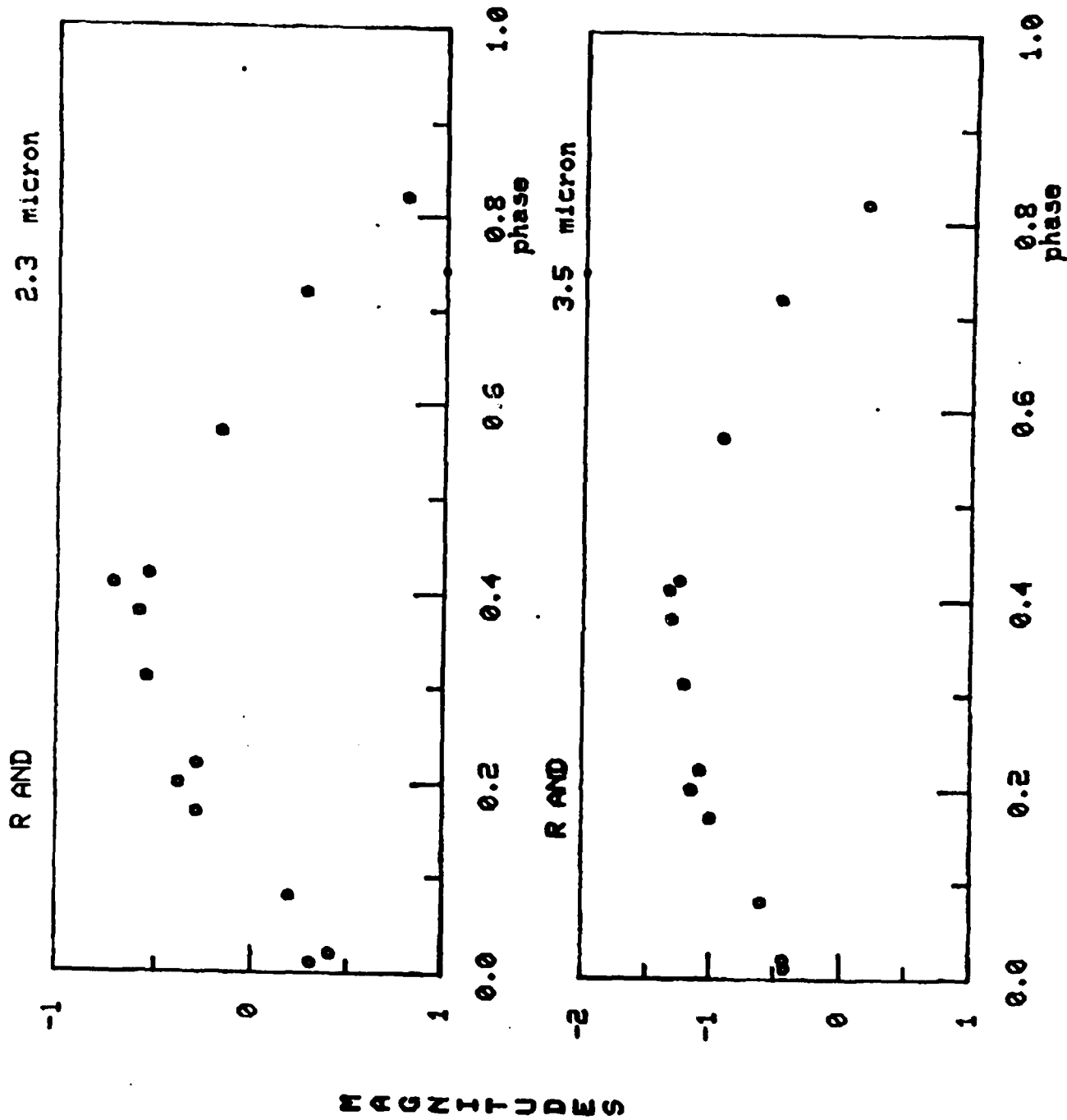
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9/19/80	89	*****	*****	*****	*****	3.42	*****	0.85
11/22/80	153	*****	*****	*****	*****	3.04	*****	0.29
5/22/81	334	*****	*****	*****	*****	3.77	*****	1.22
6/17/81	360	*****	*****	*****	*****	3.99	*****	1.13
9/21/81	456	*****	7.60	7.51	*****	*****	3.51	0.94
10/19/81	484	*****	*****	*****	*****	*****	3.83	1.13
7/2/82	740	*****	*****	*****	*****	*****	3.40	0.87
9/29/82	830	*****	*****	*****	*****	*****	3.47	0.91
05/30/83	1072	*****	*****	8.99	*****	*****	4.36	1.84

## GL 3068

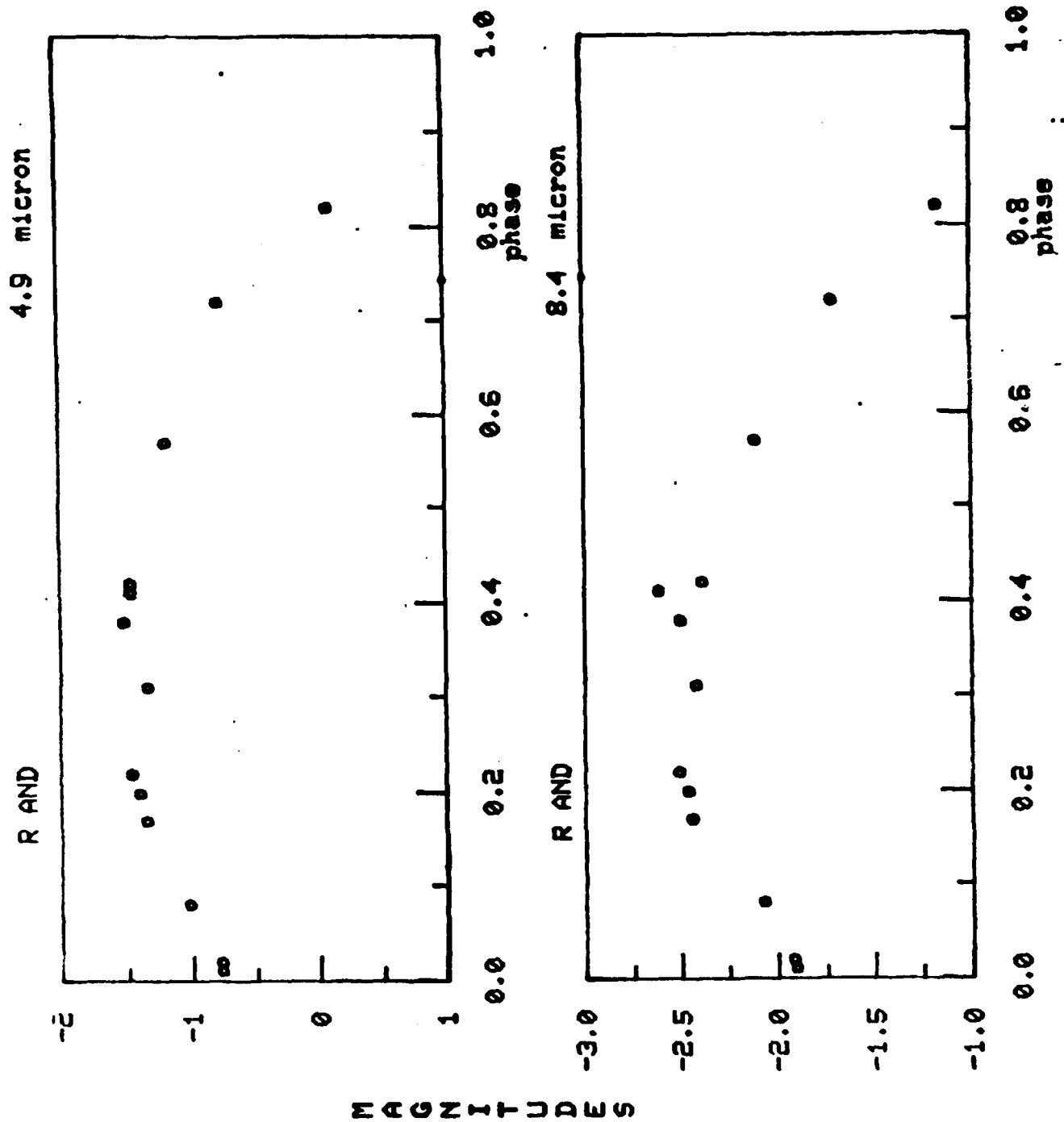
DATES	DAYS	8.4	8.6	10.3	10.6	11.3	12.8	18.0
6/22/80	0	-2.30	*****	*****	-2.91	*****	-3.49	*****
9/19/80	89	-2.75	*****	*****	-3.38	*****	-3.93	*****
11/22/80	153	-3.00	*****	*****	-3.67	*****	-4.18	*****
5/22/81	334	-2.49	*****	*****	-3.25	*****	-3.78	*****
6/17/81	360	-2.43	*****	*****	-3.16	*****	*****	*****
9/21/81	456	*****	-2.07	-2.33	*****	-2.37	-3.08	-4.78
10/19/81	484	*****	-2.90	-3.51	*****	-3.72	-4.17	-5.20
7/2/82	740	*****	-2.93	-3.38	*****	-3.54	-4.16	-4.50
9/29/82	830	*****	-2.89	-3.39	*****	-3.56	-3.98	-4.87
05/30/83	1072	*****	-2.42	-2.83	*****	-3.38	-3.79	-4.25

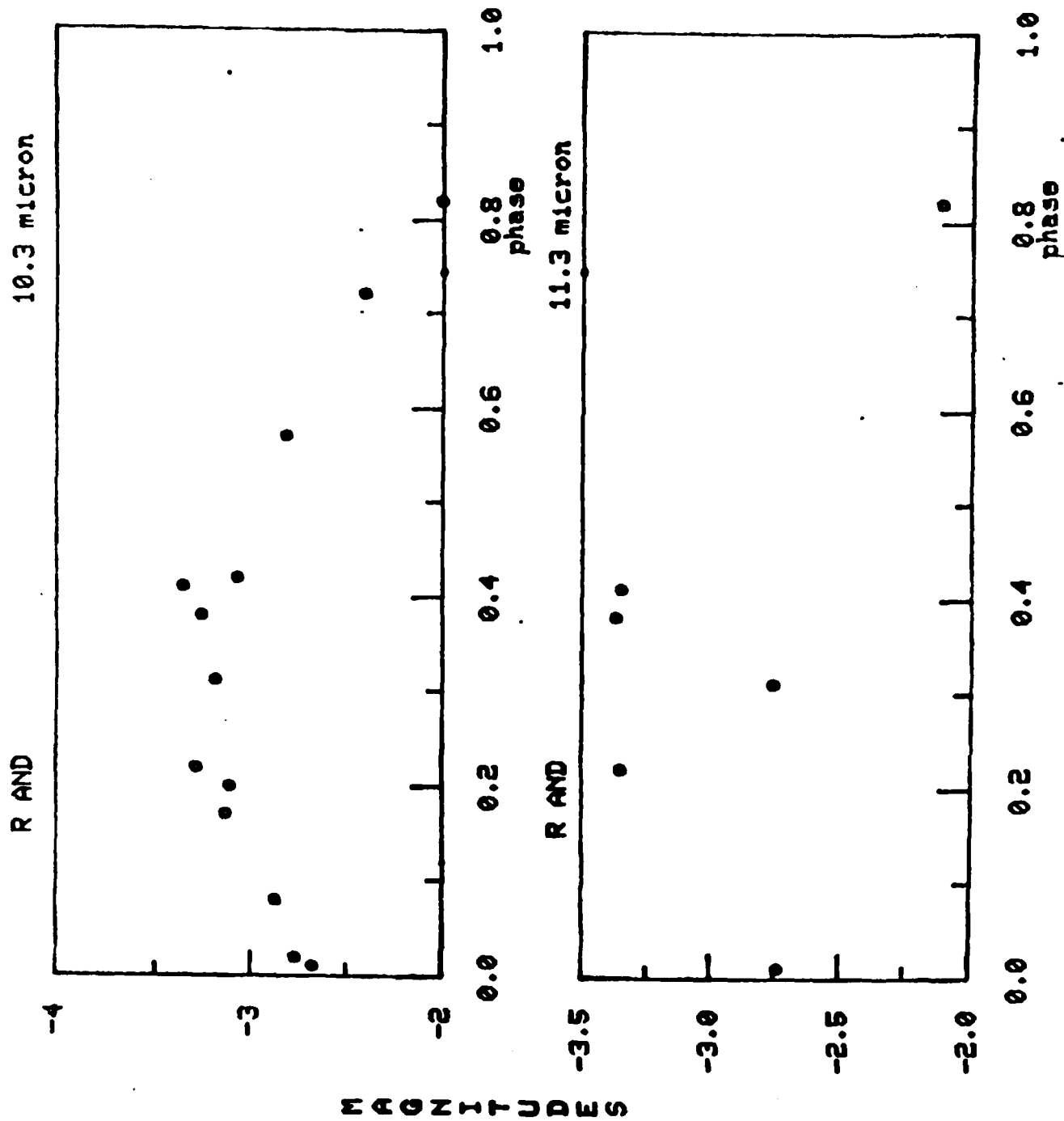
FIGURE 1

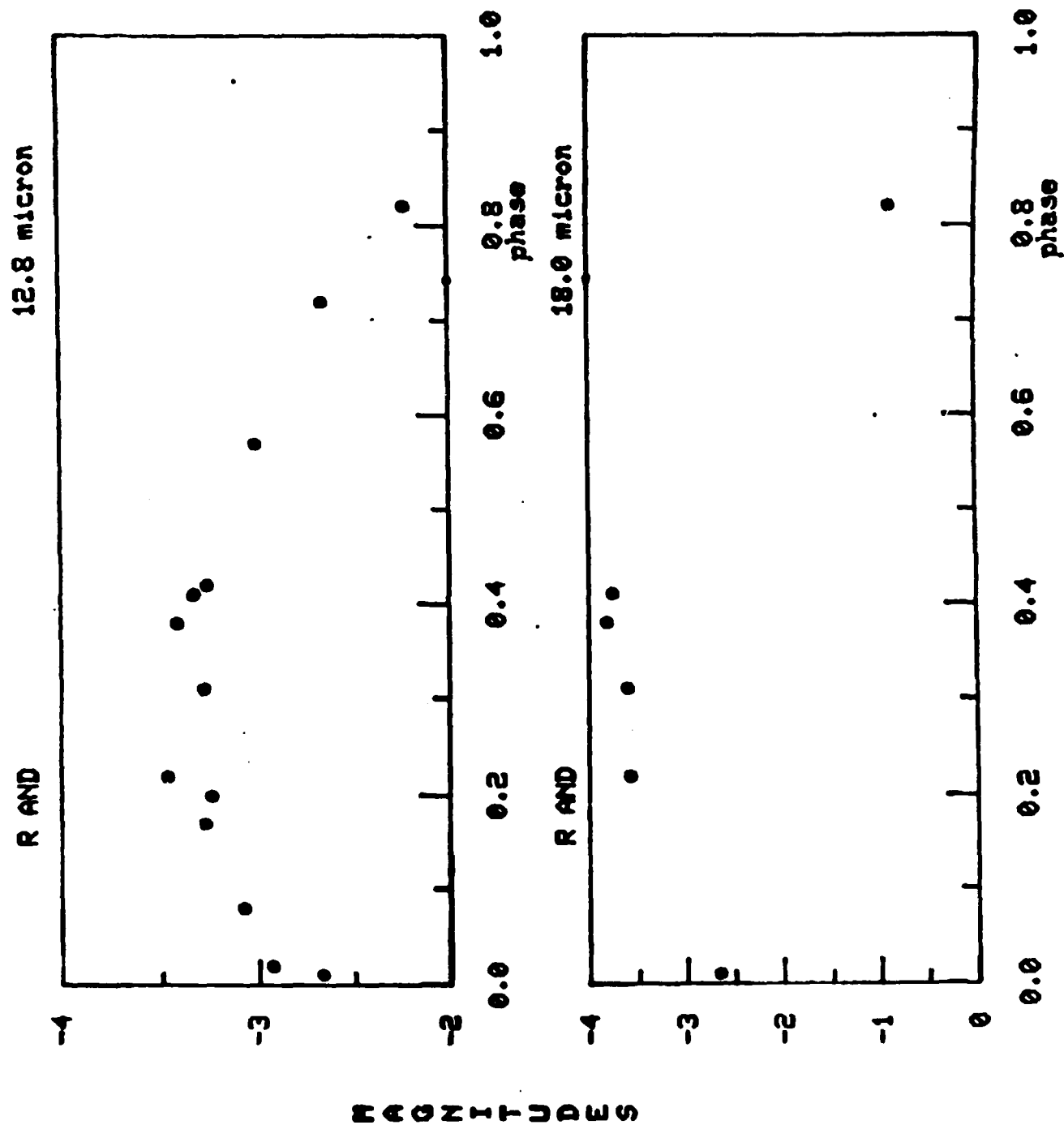








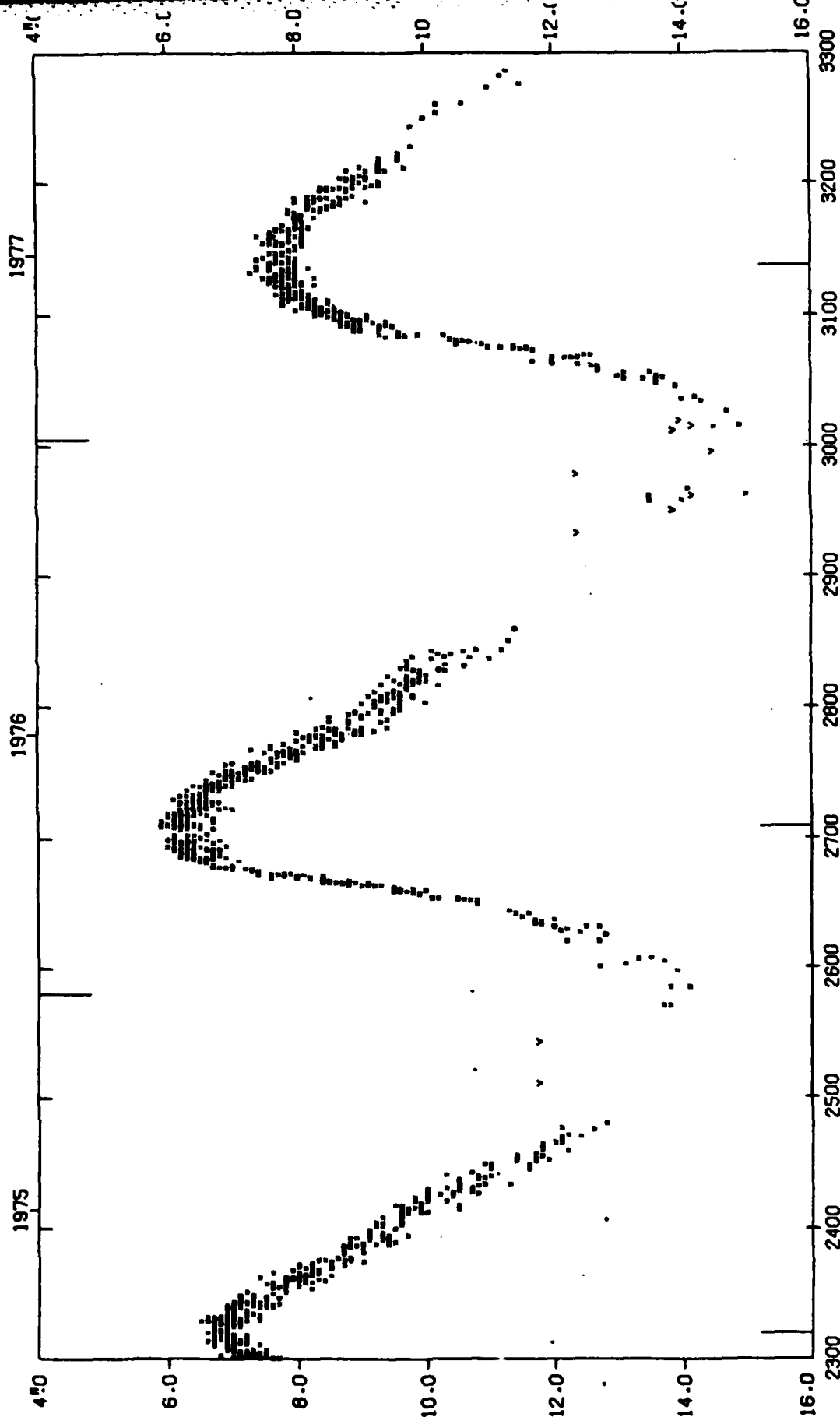




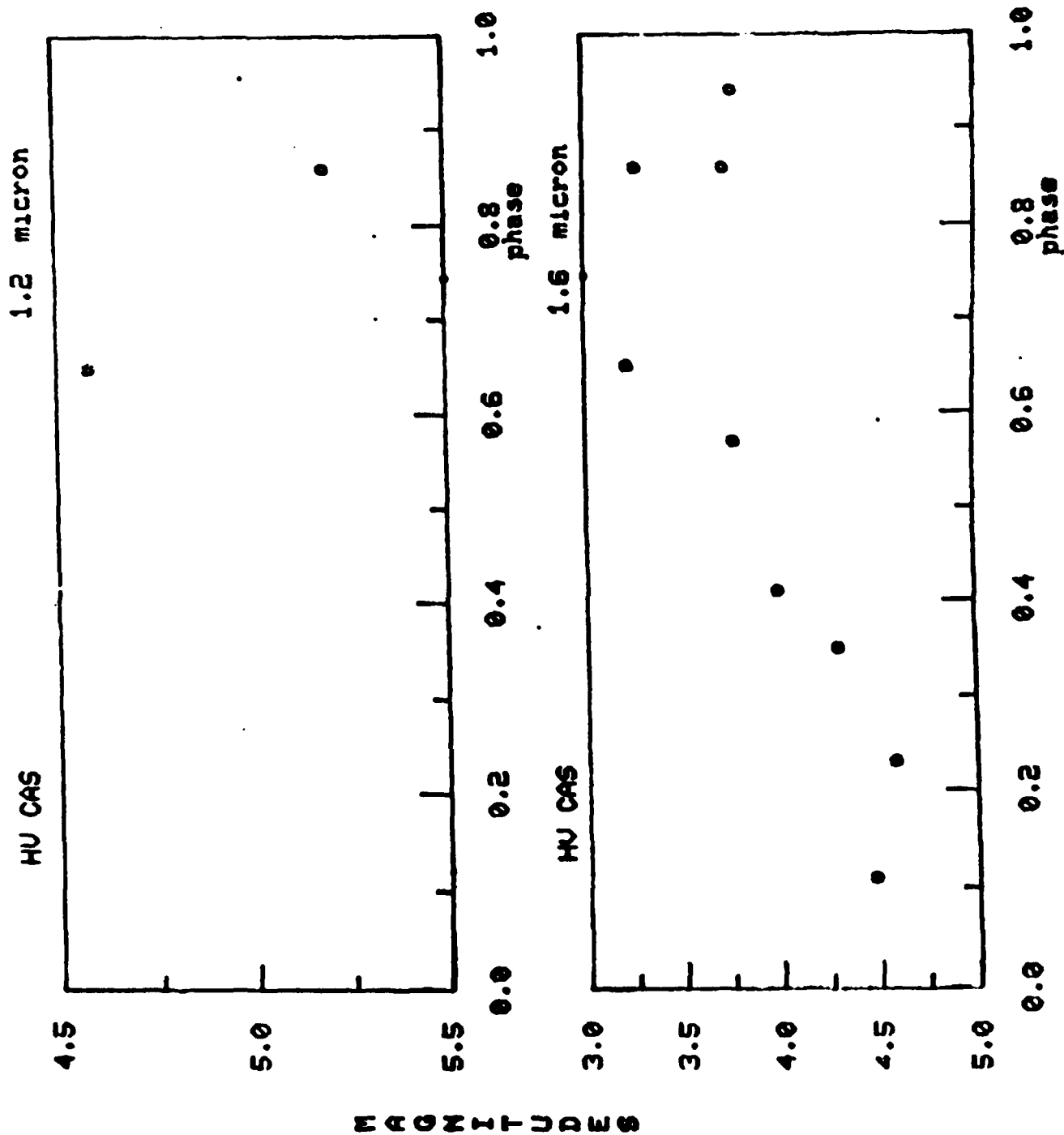
# AAVSO Report 38

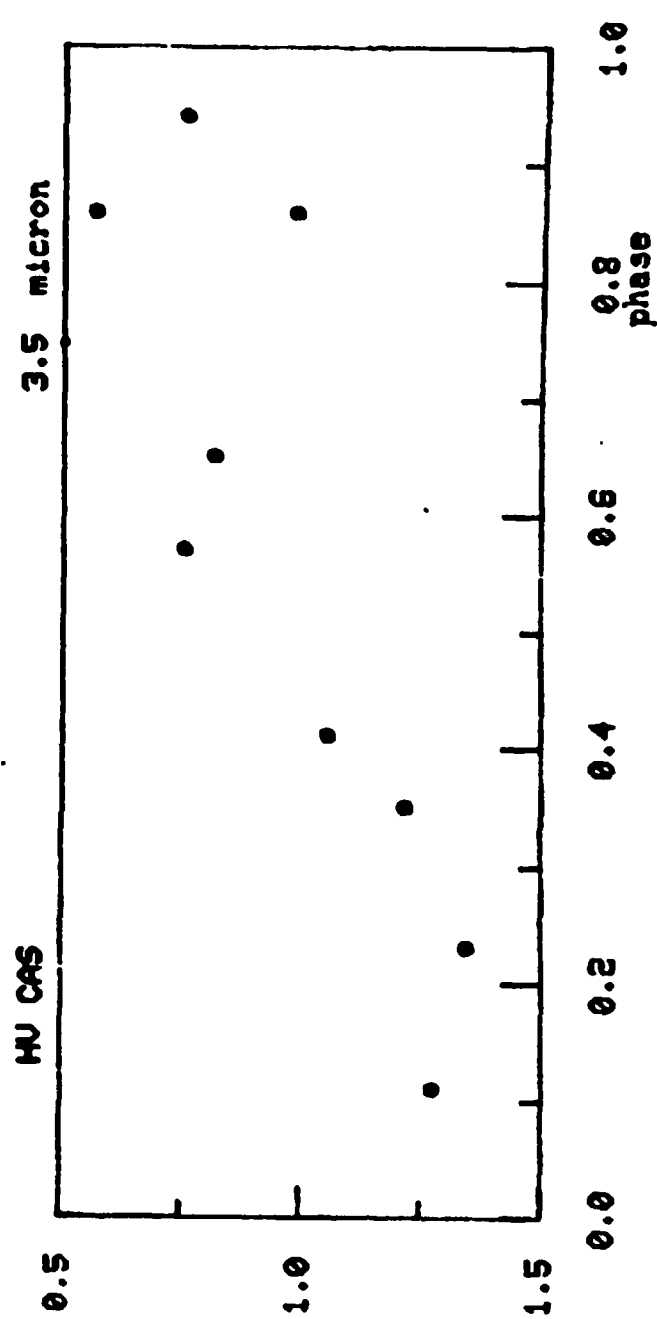
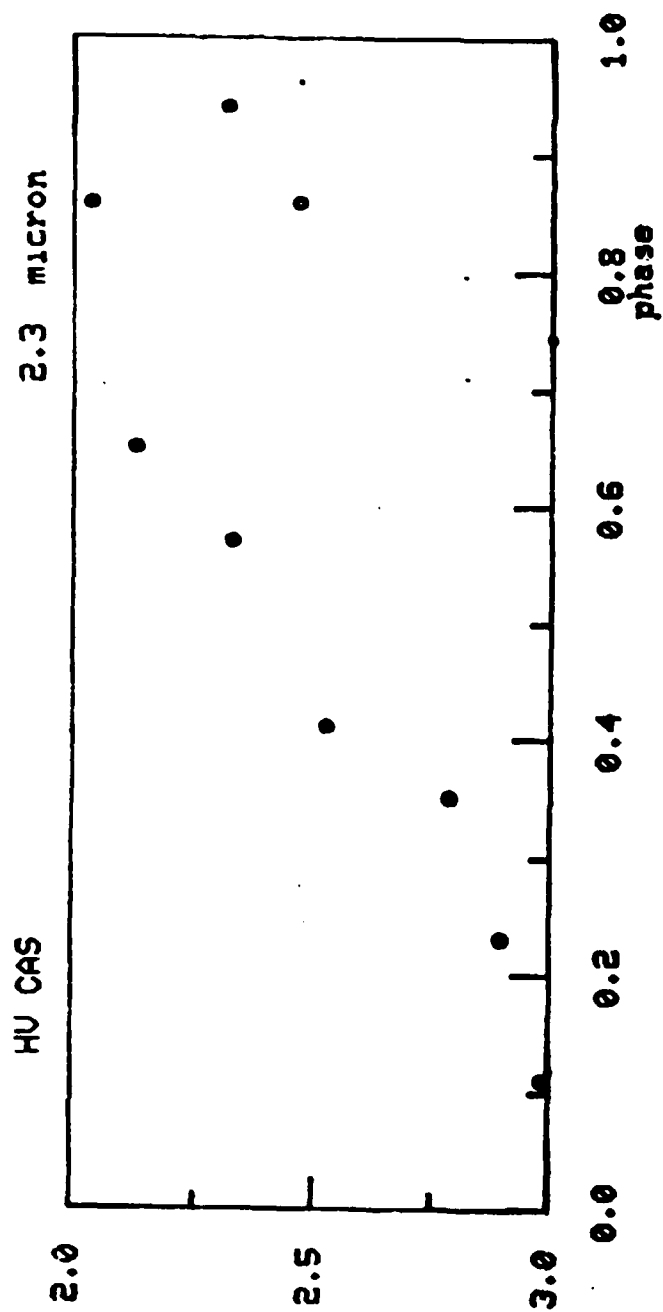
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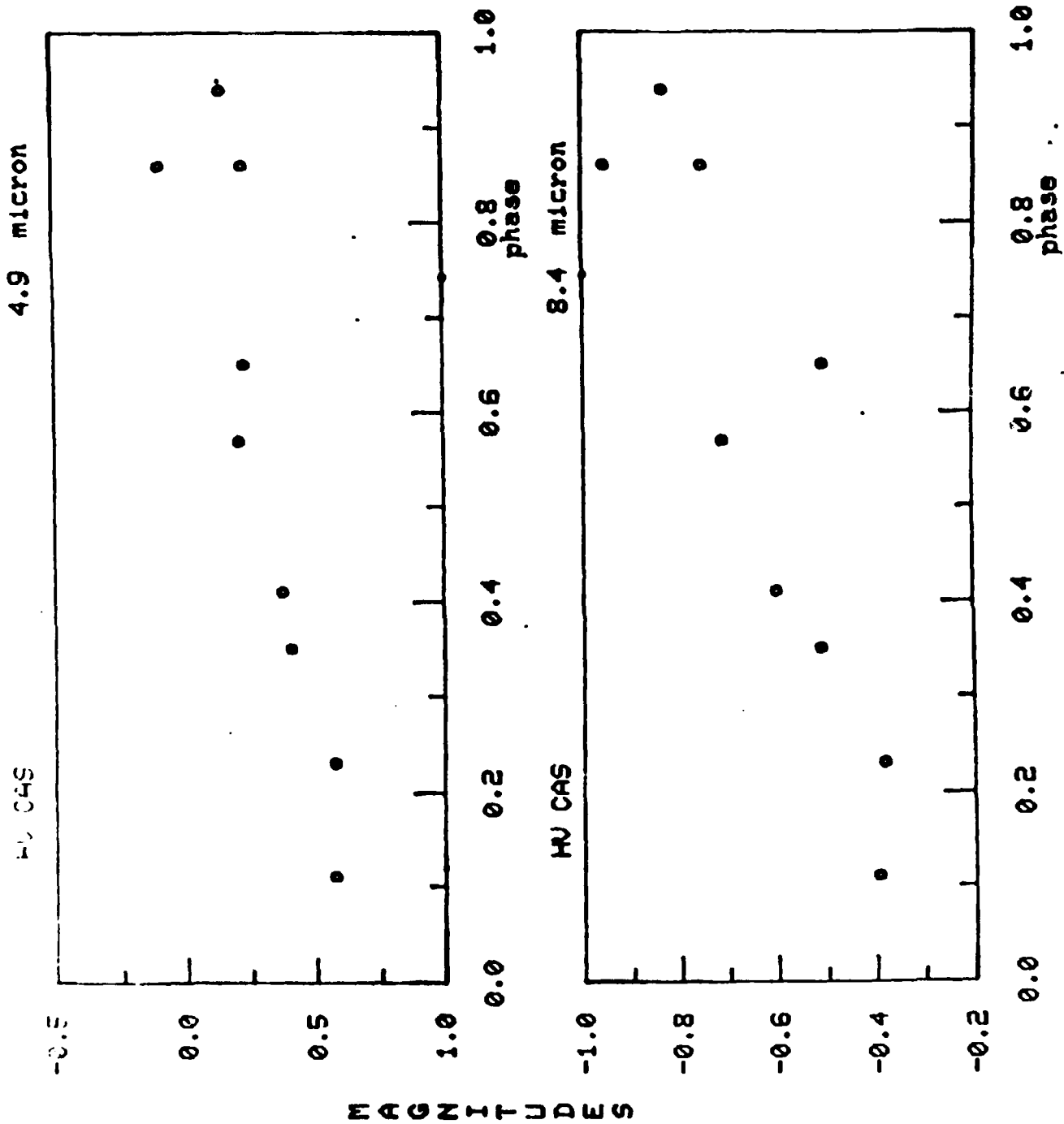
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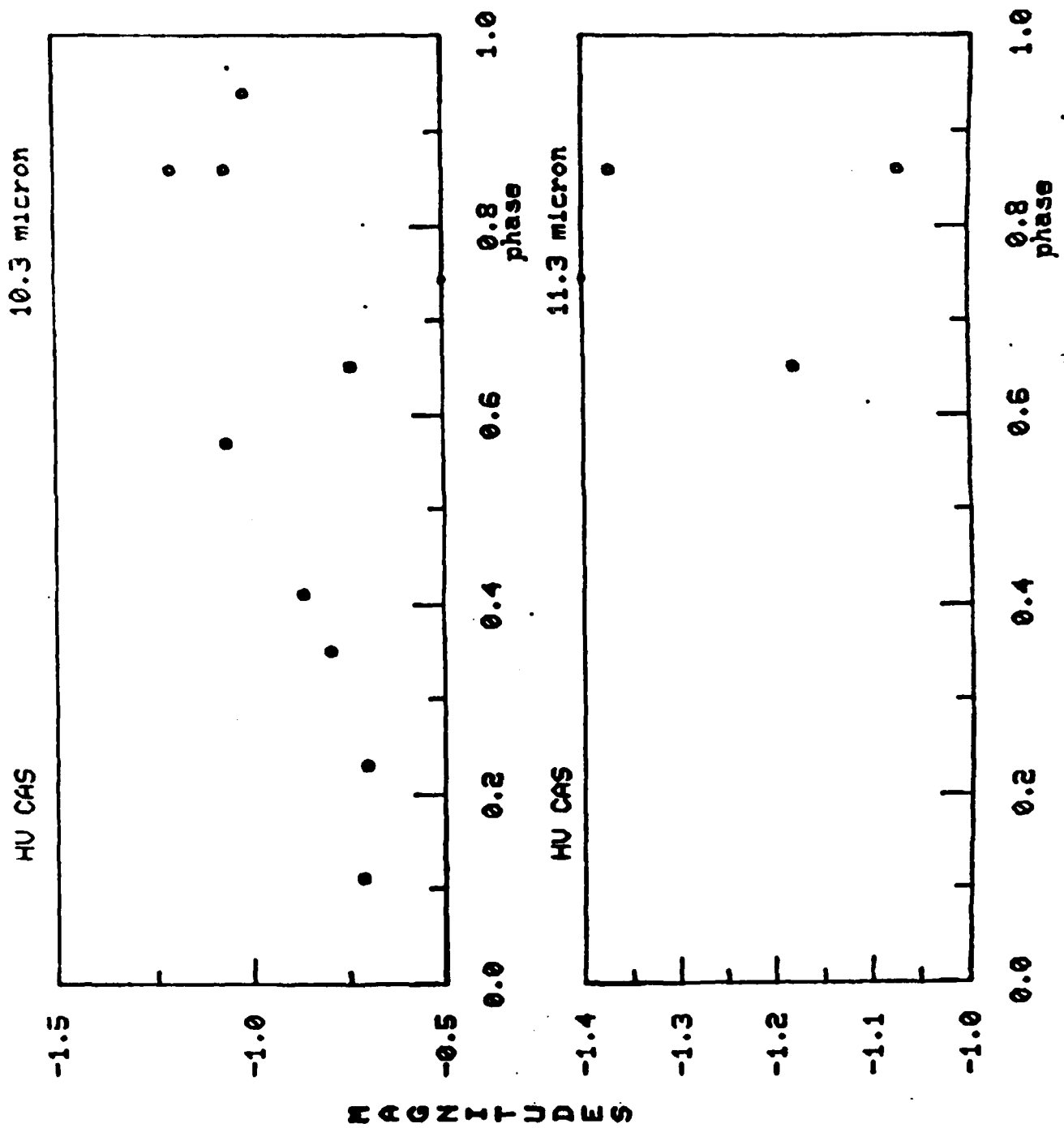


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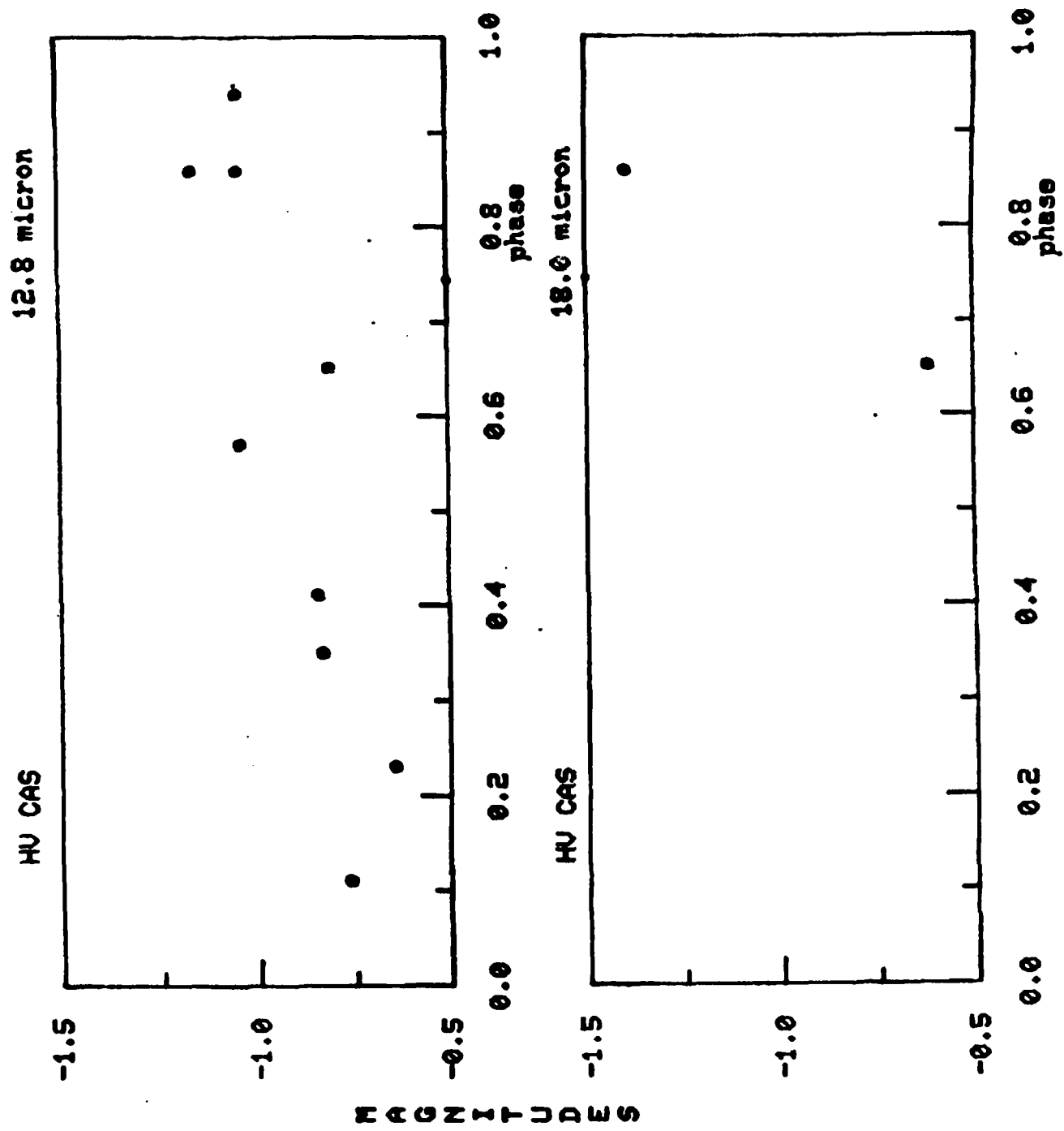


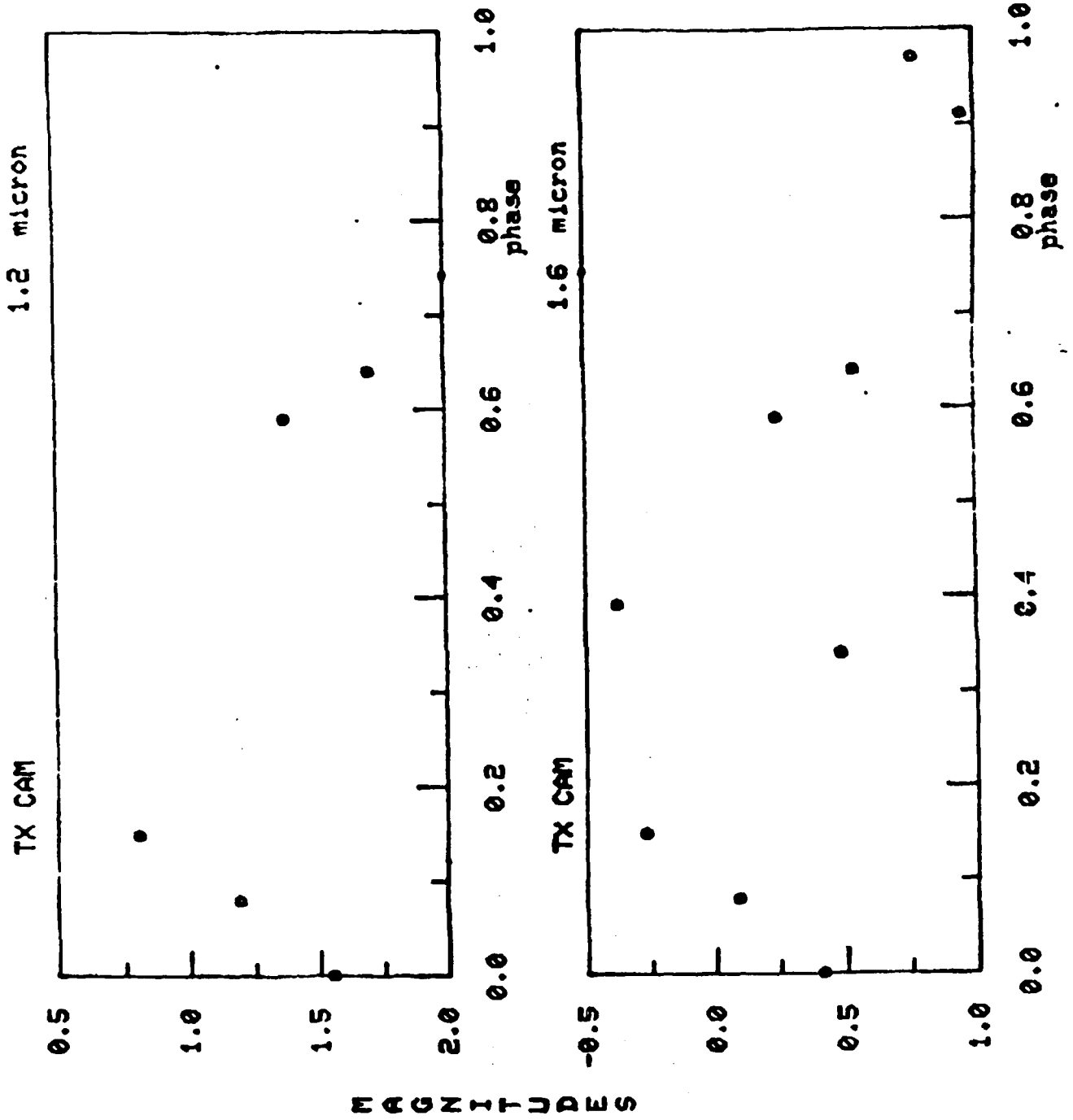


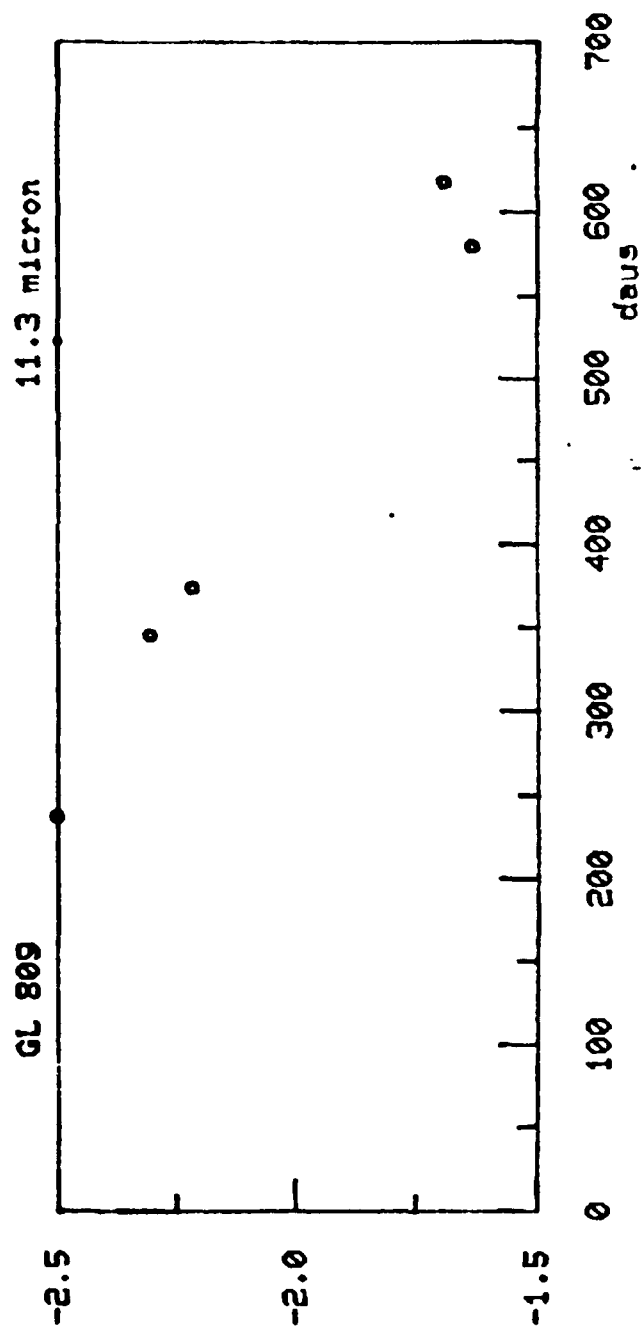
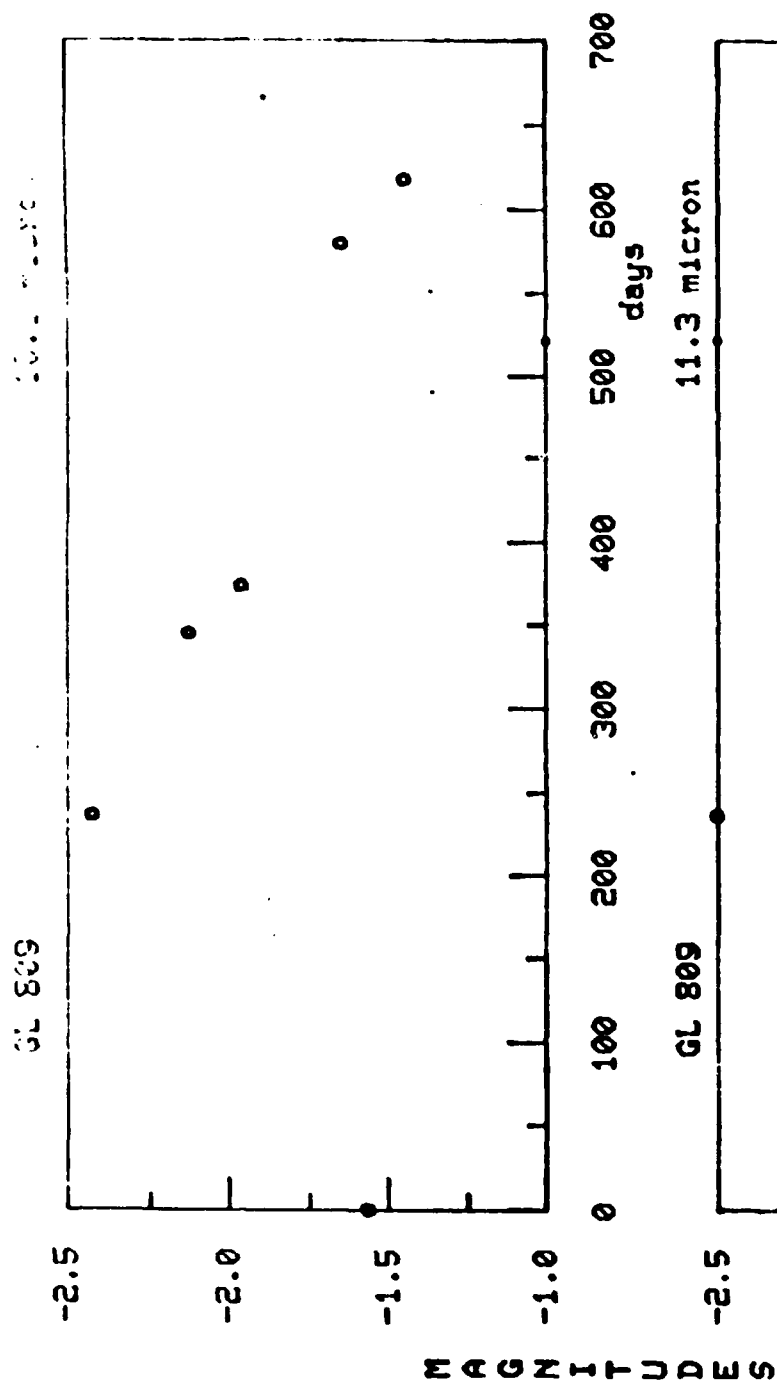


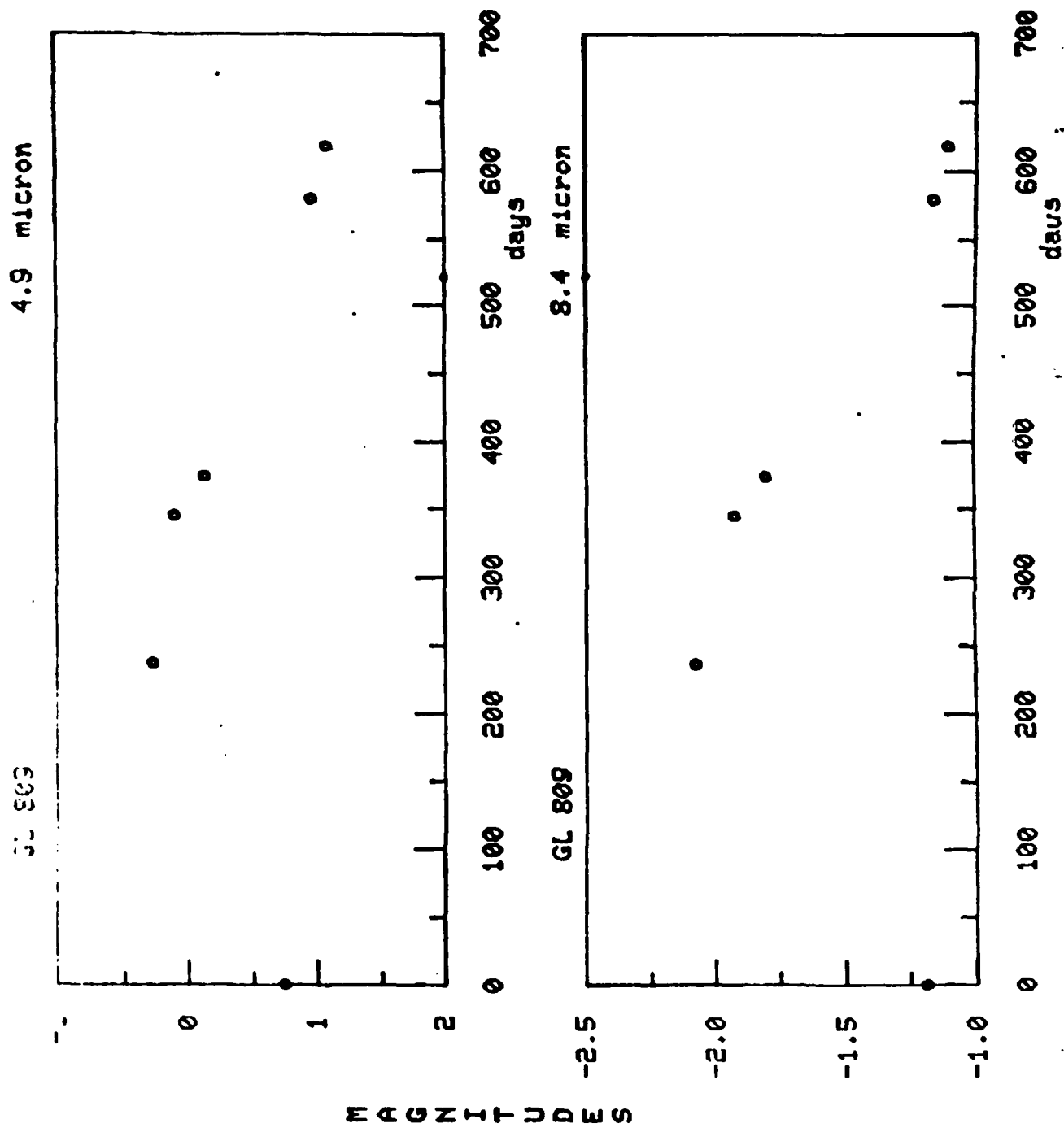


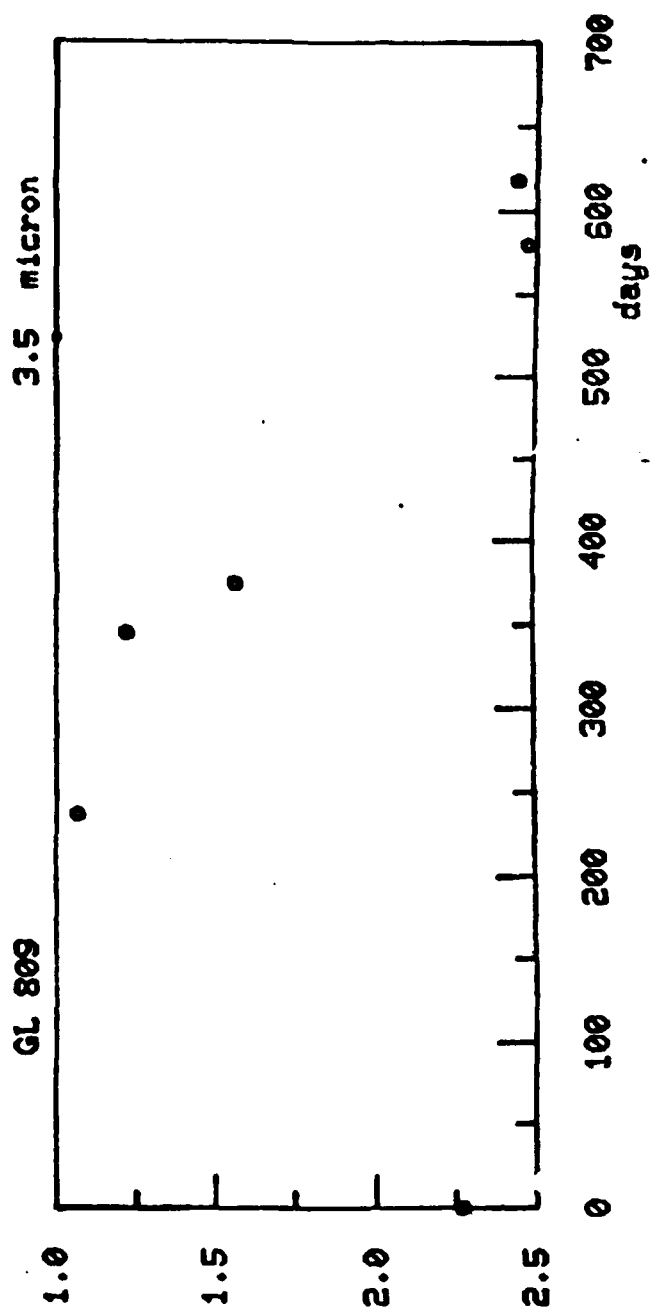
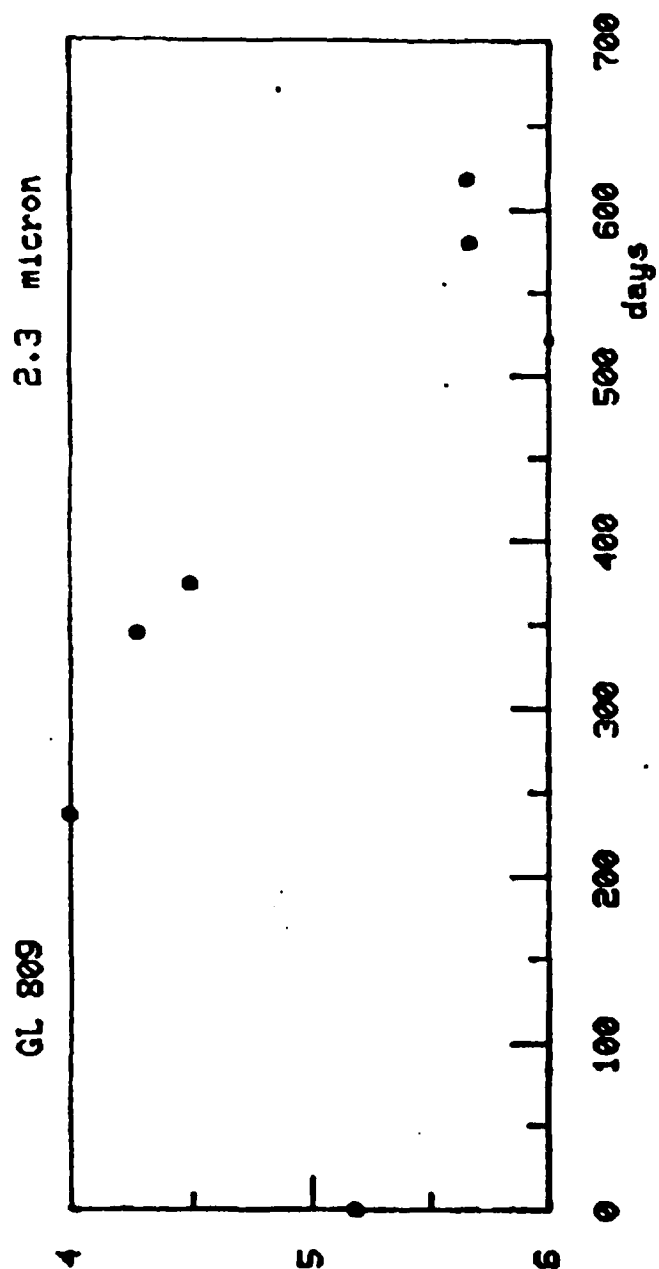


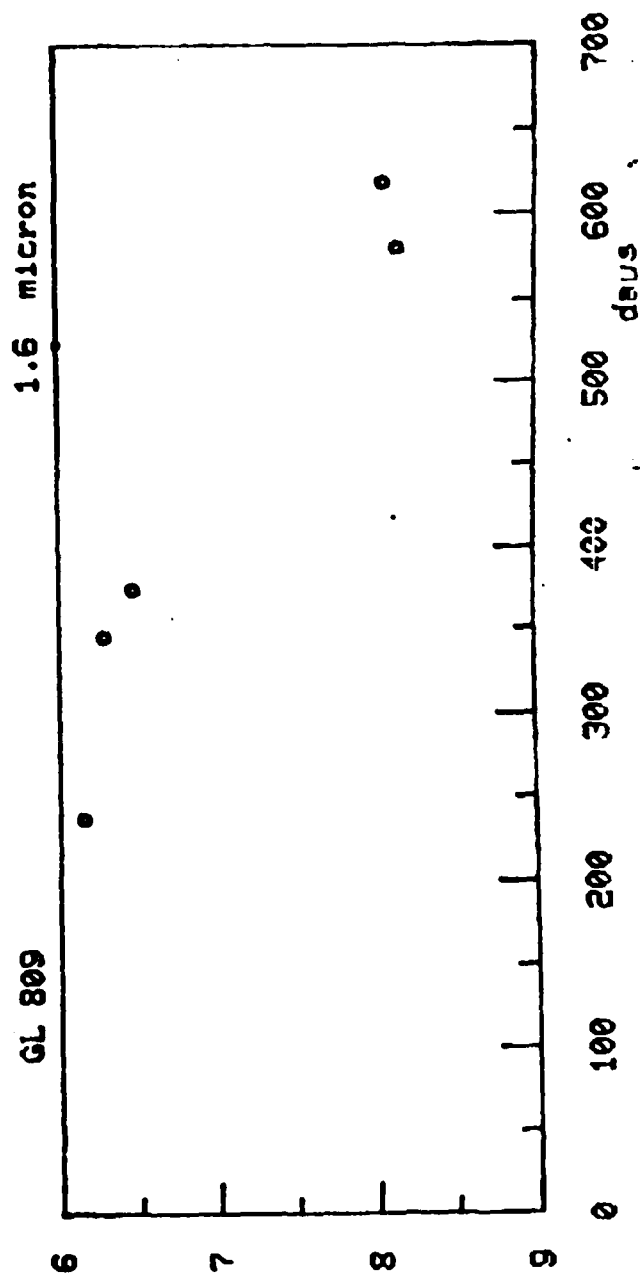
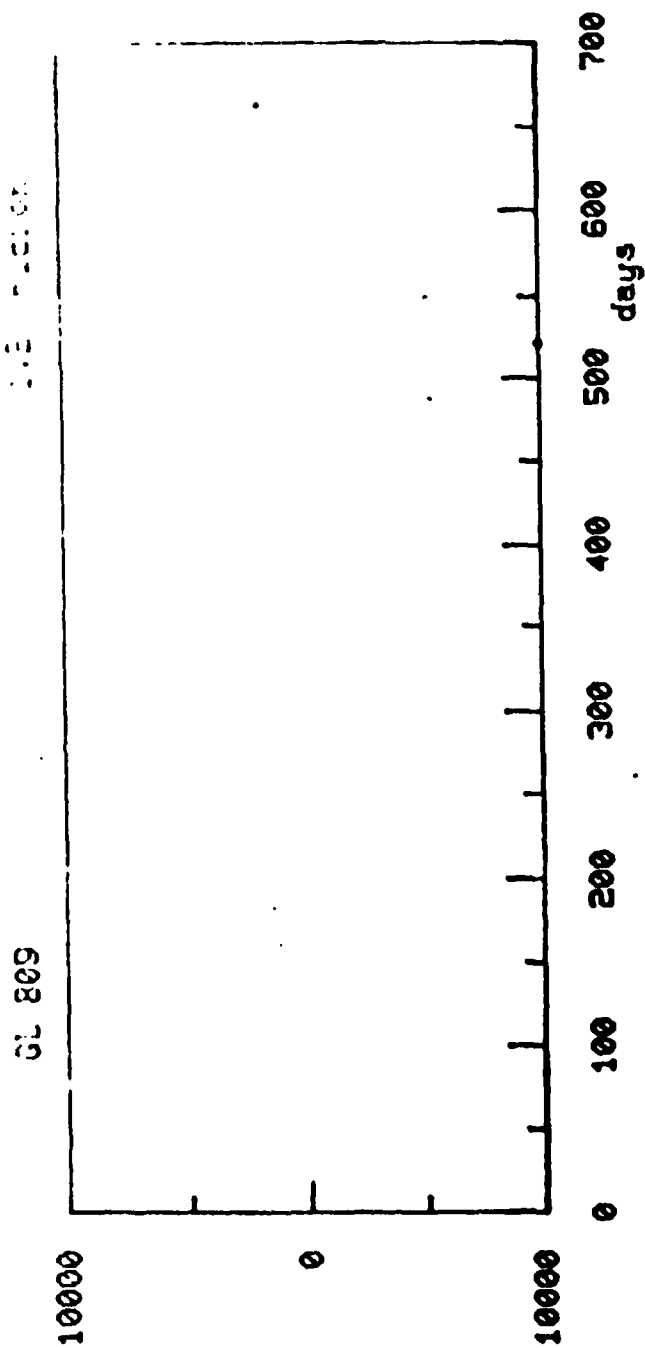


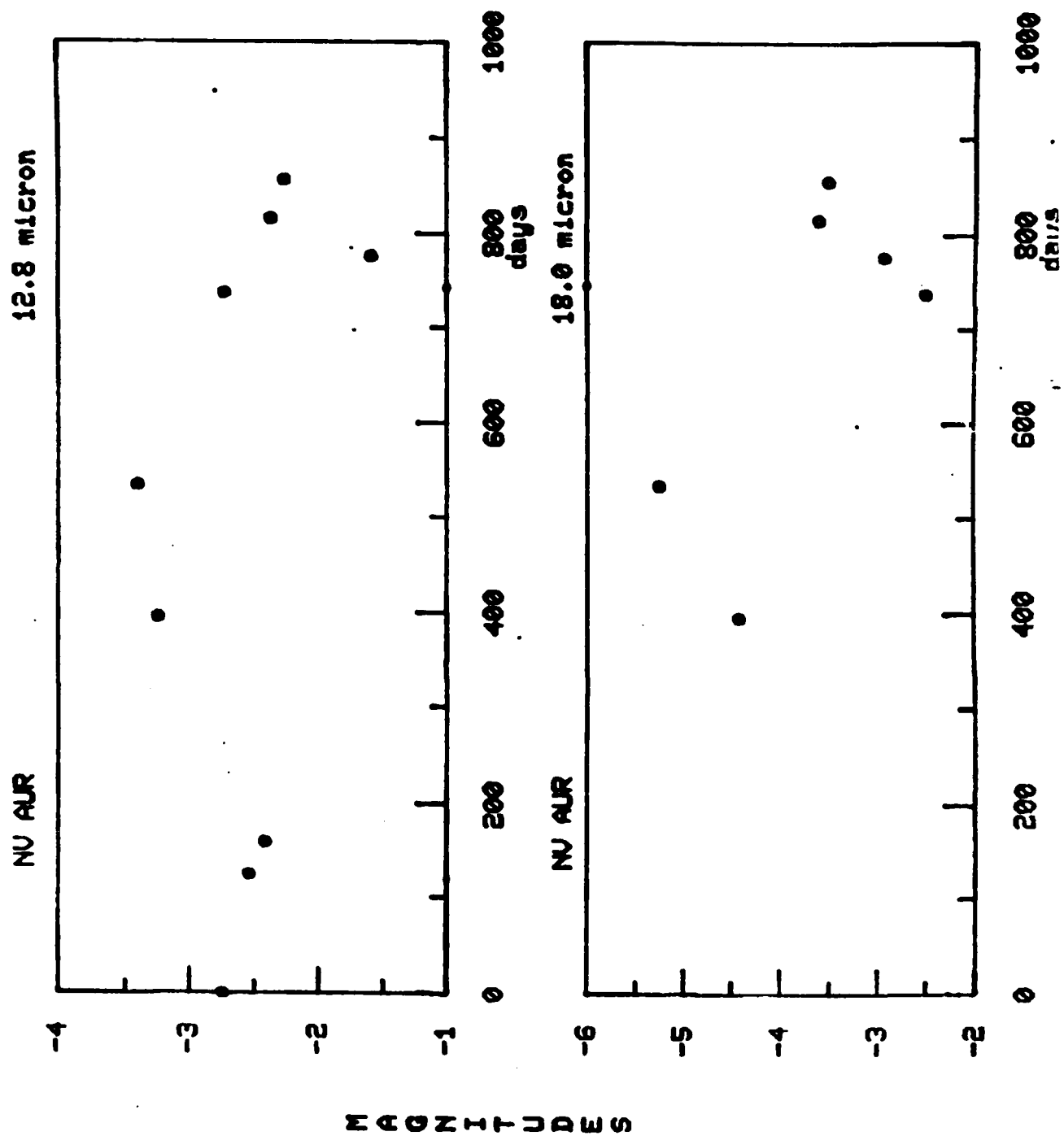


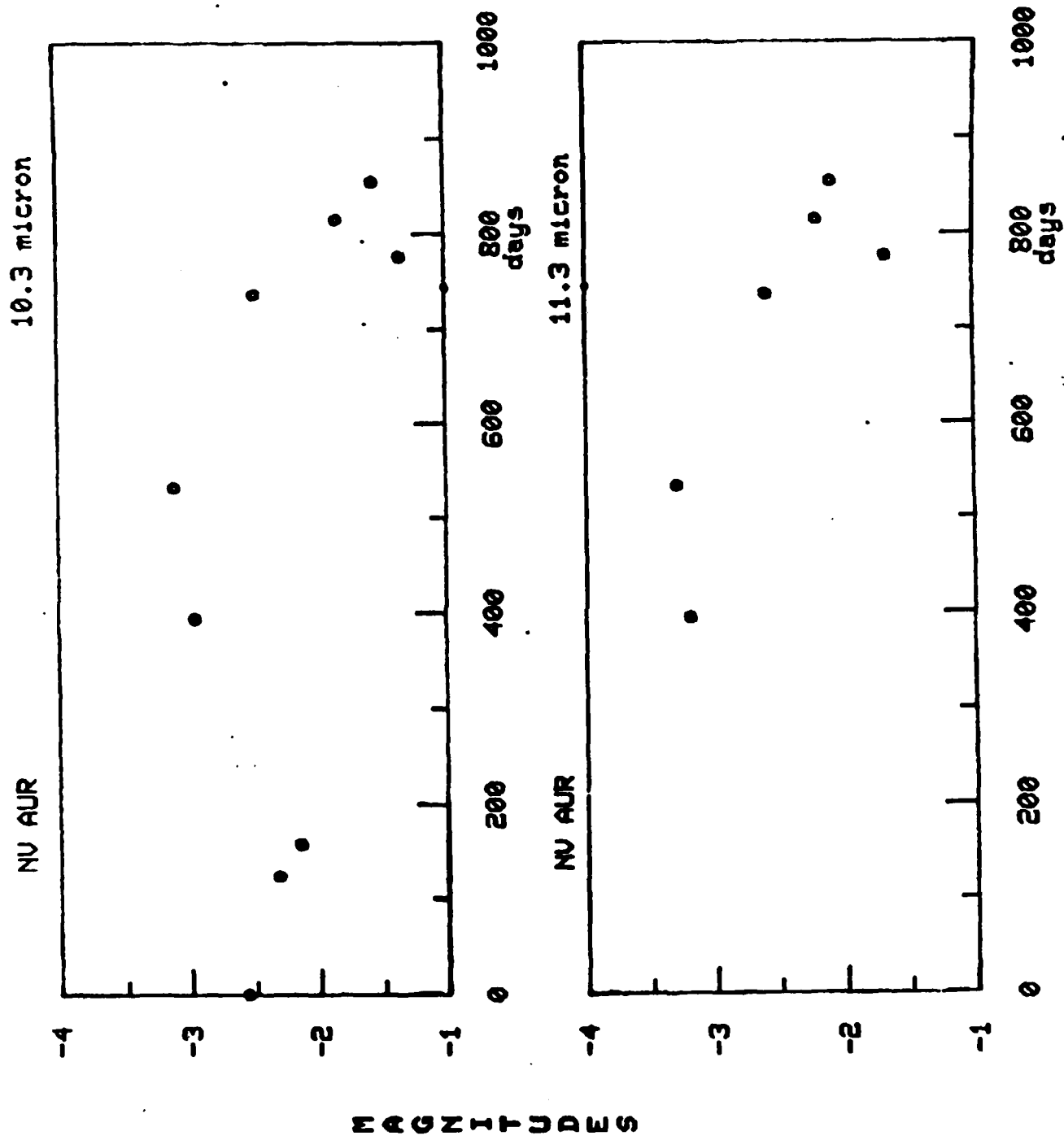




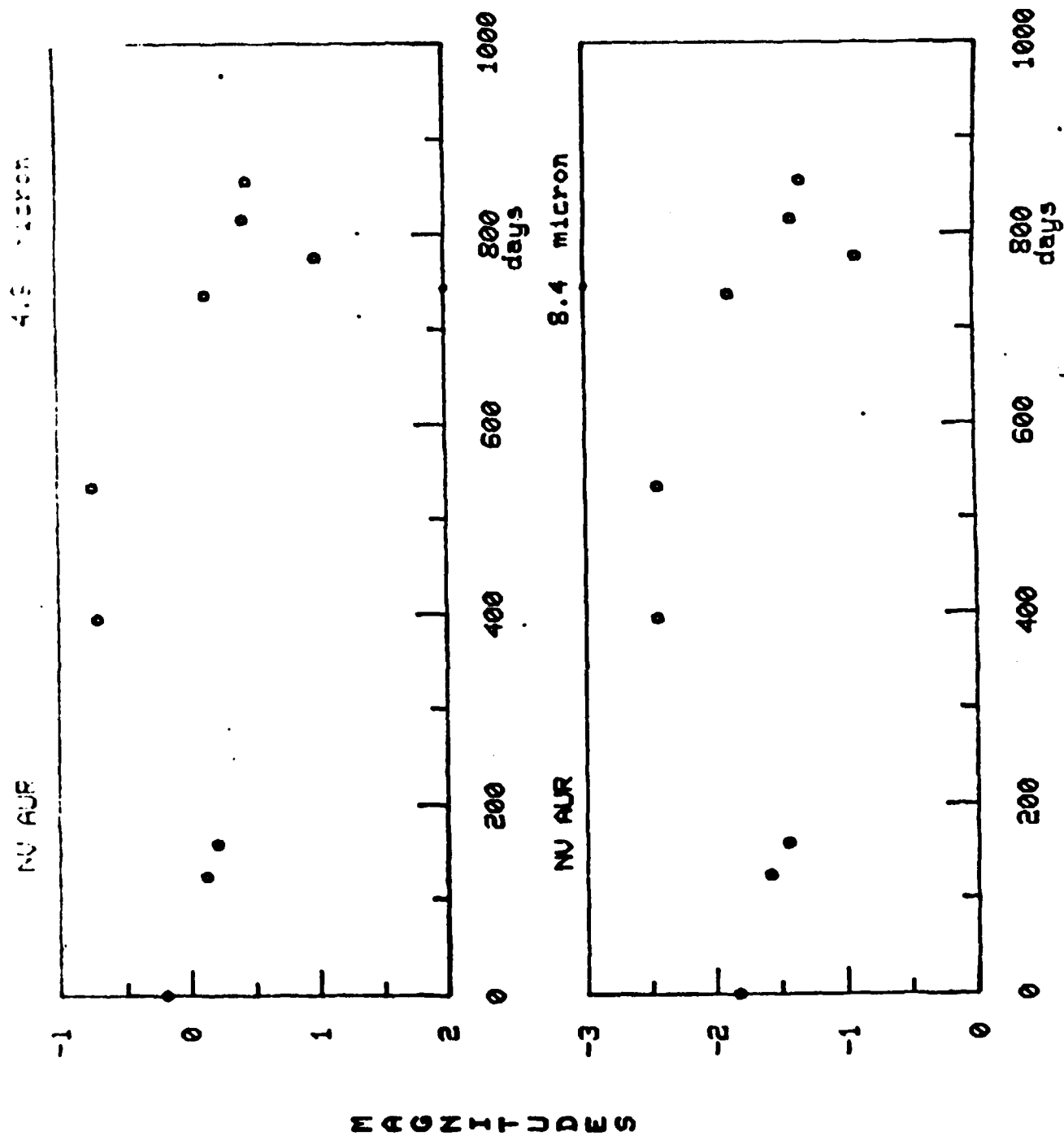


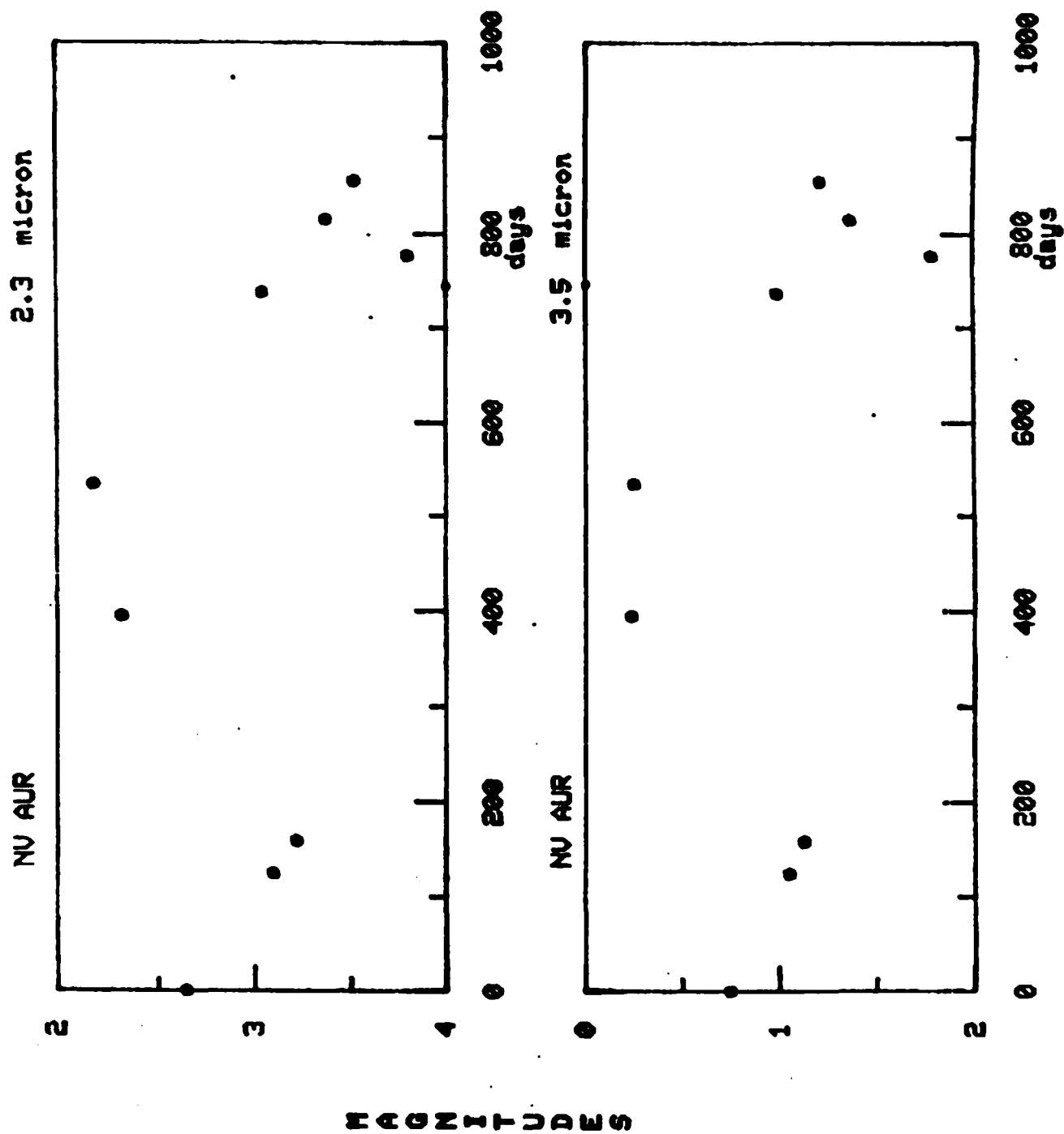


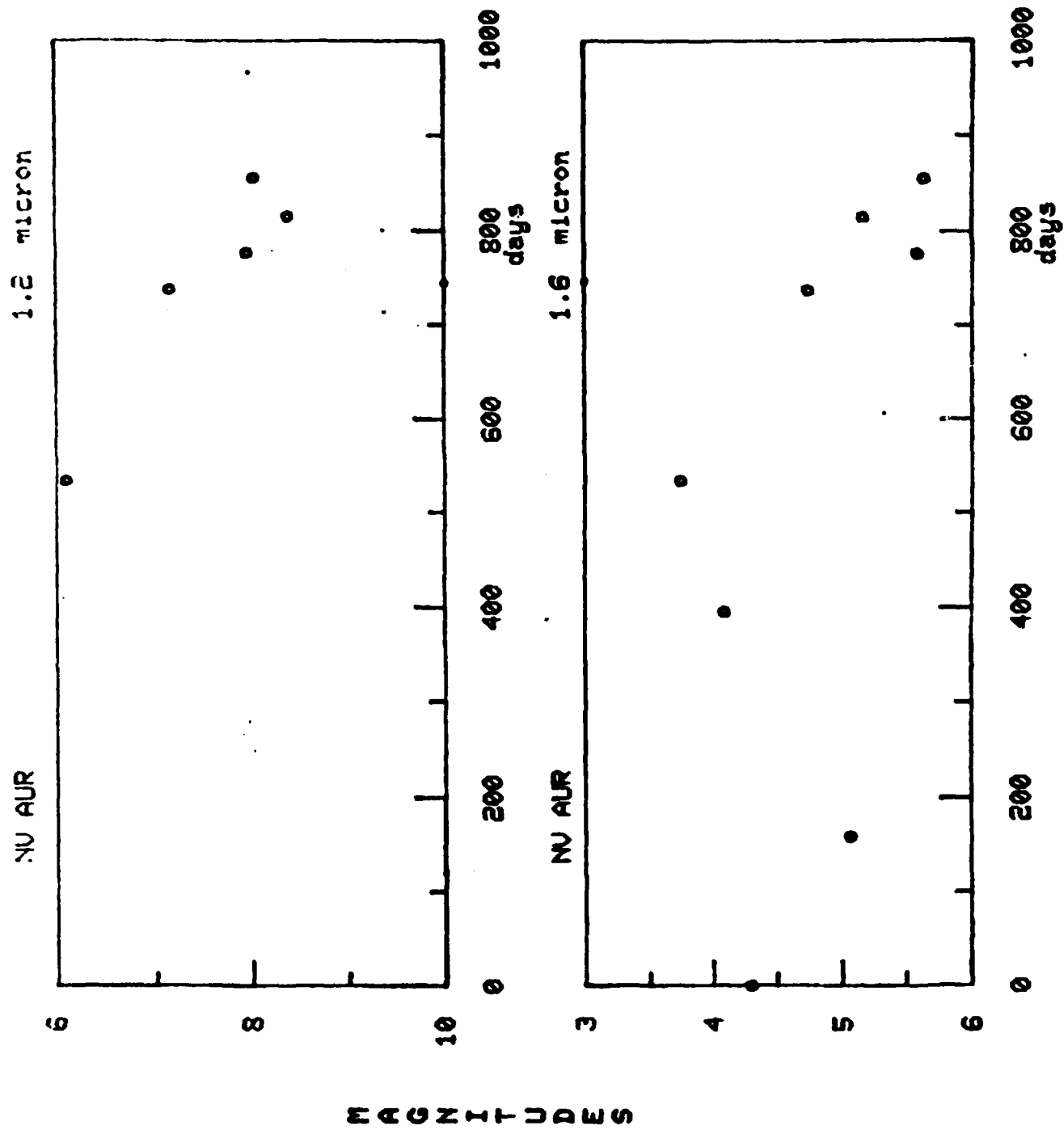












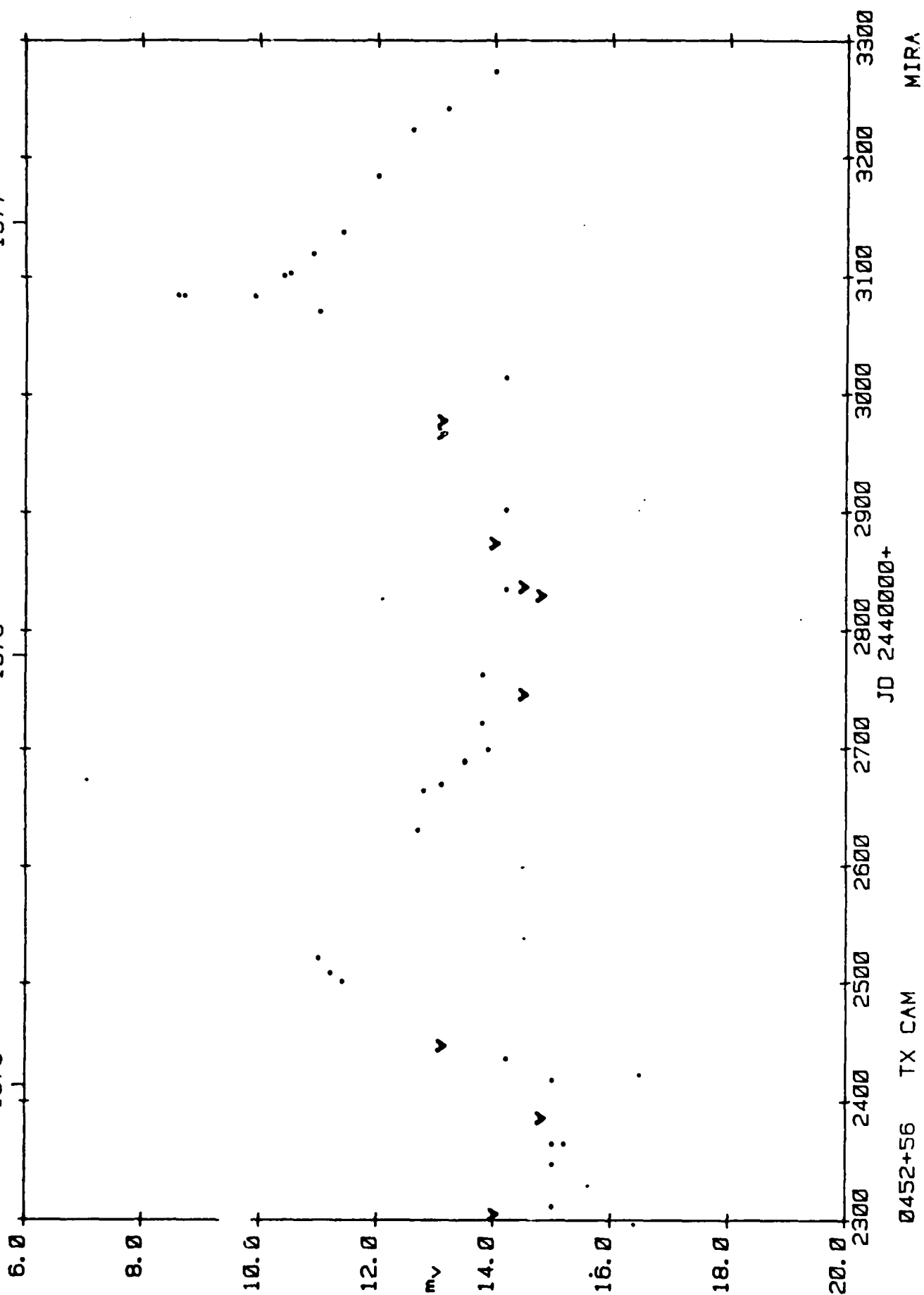
# AAVSO Report 38

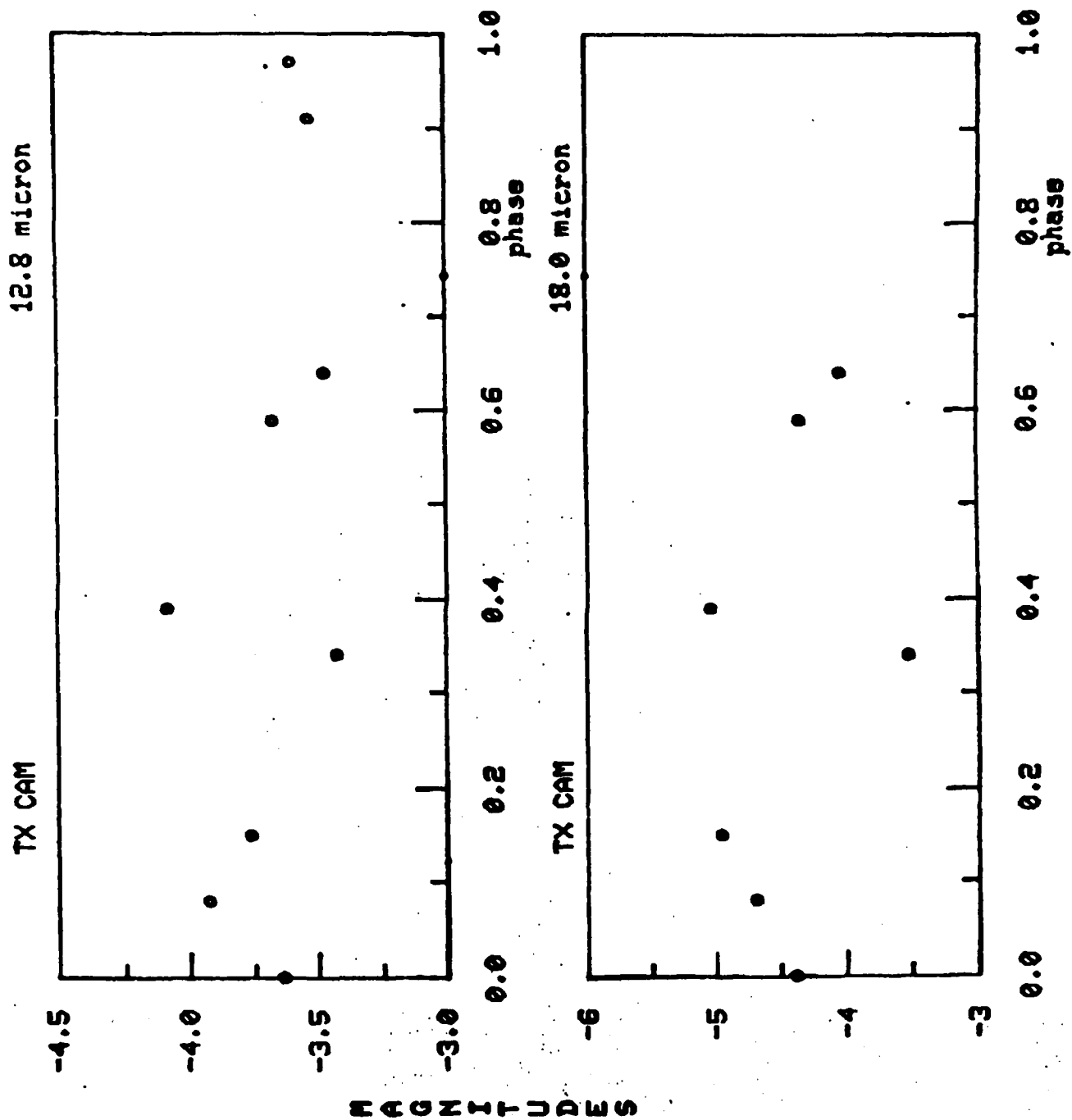
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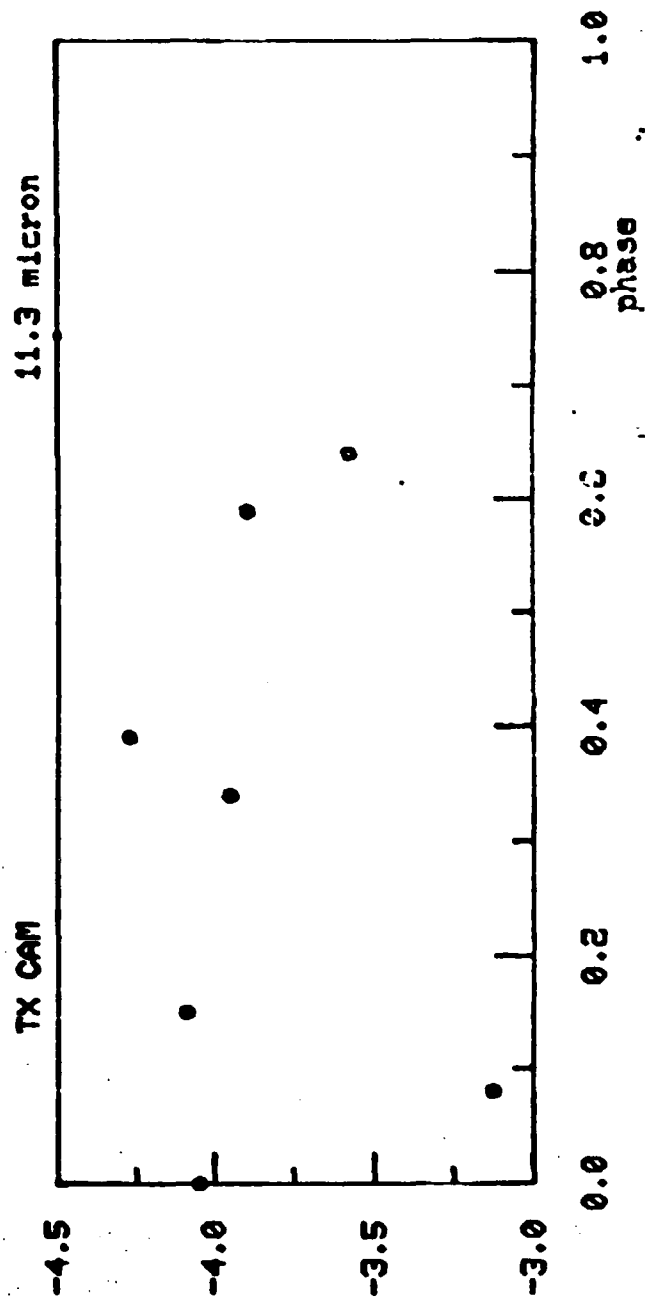
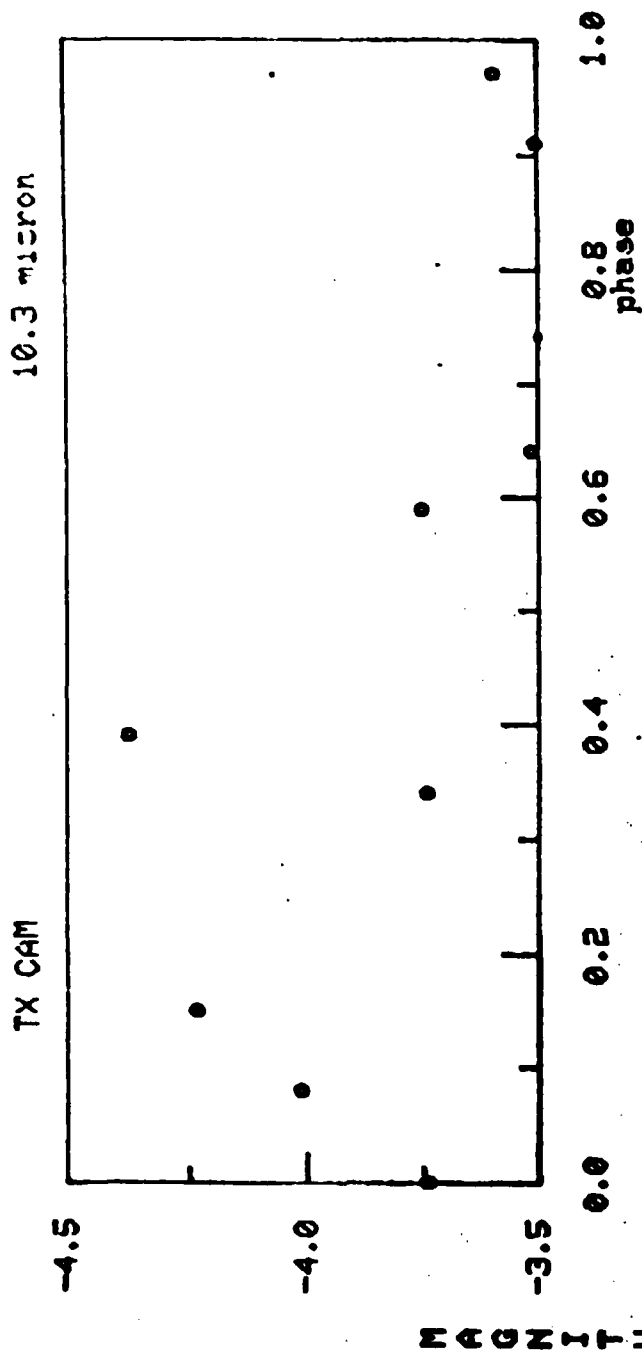
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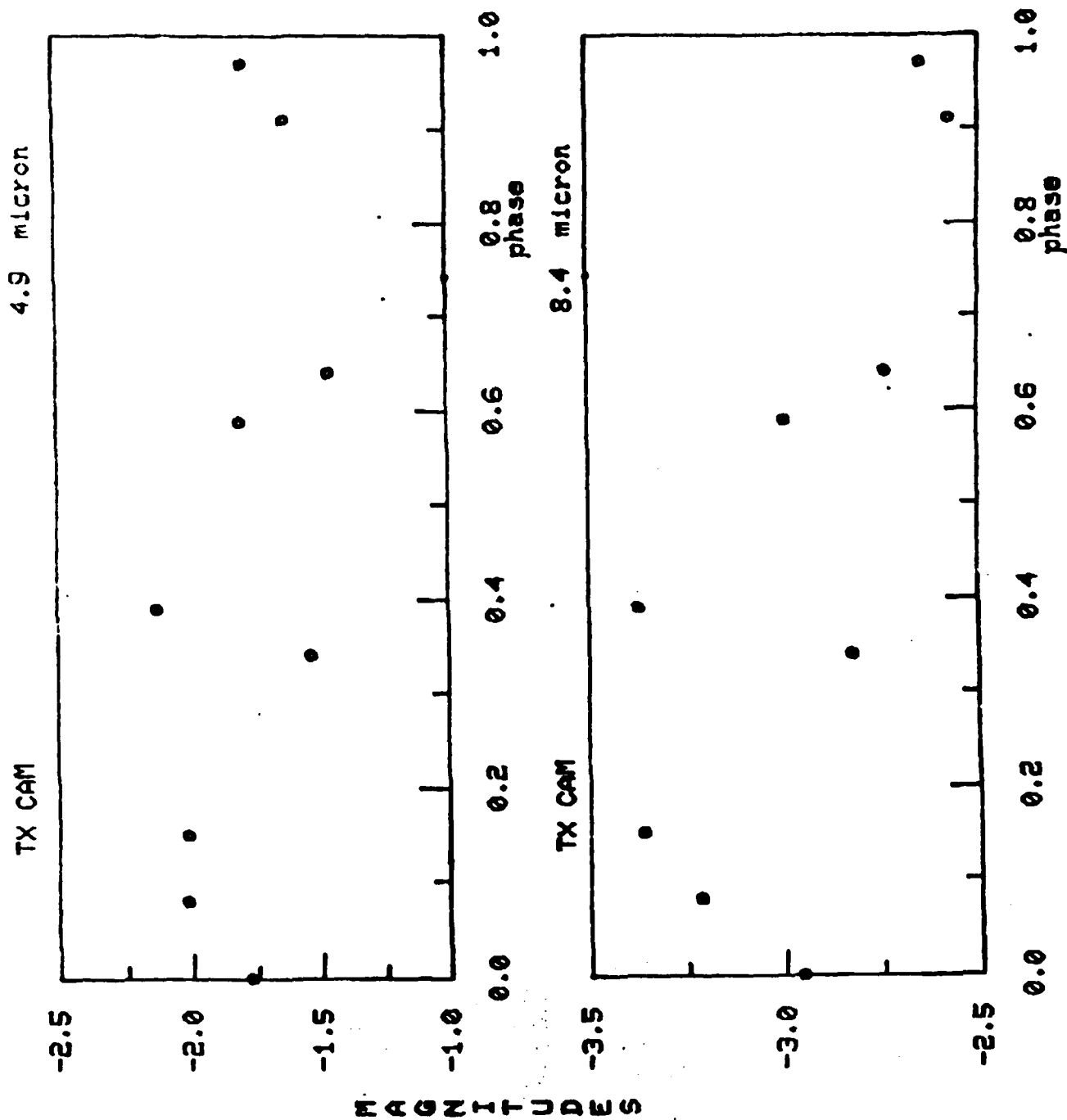
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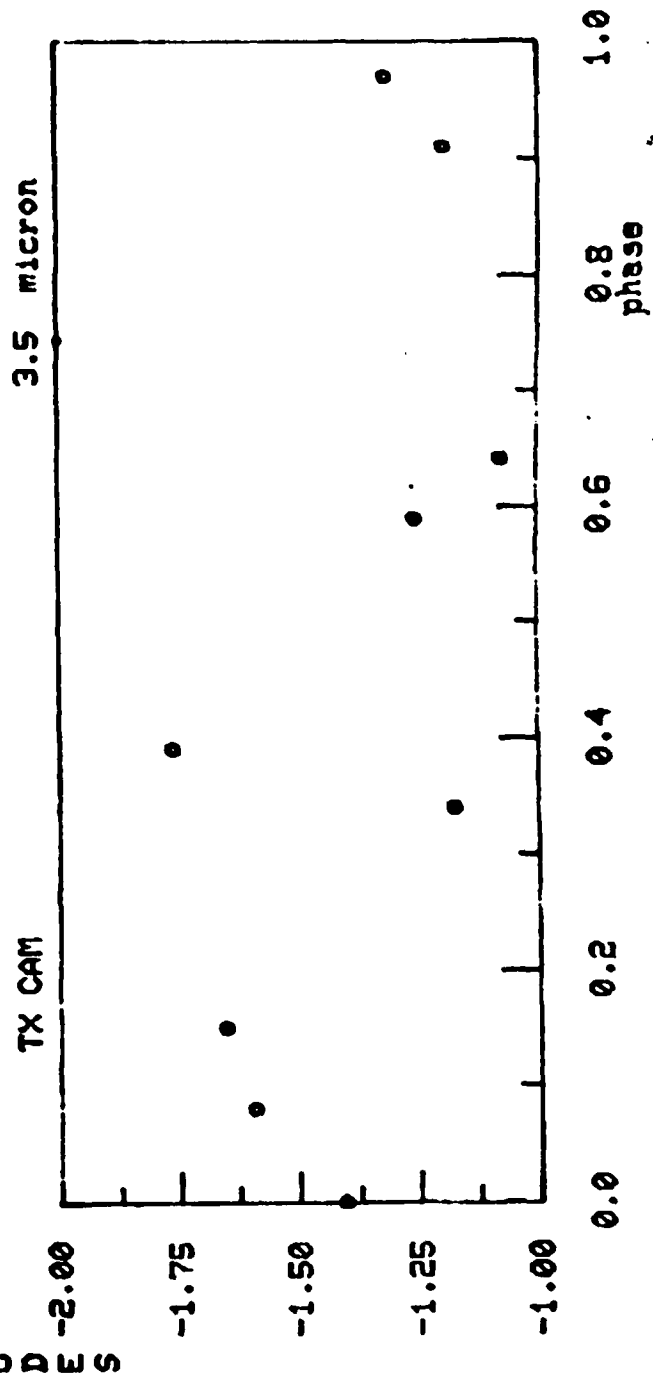
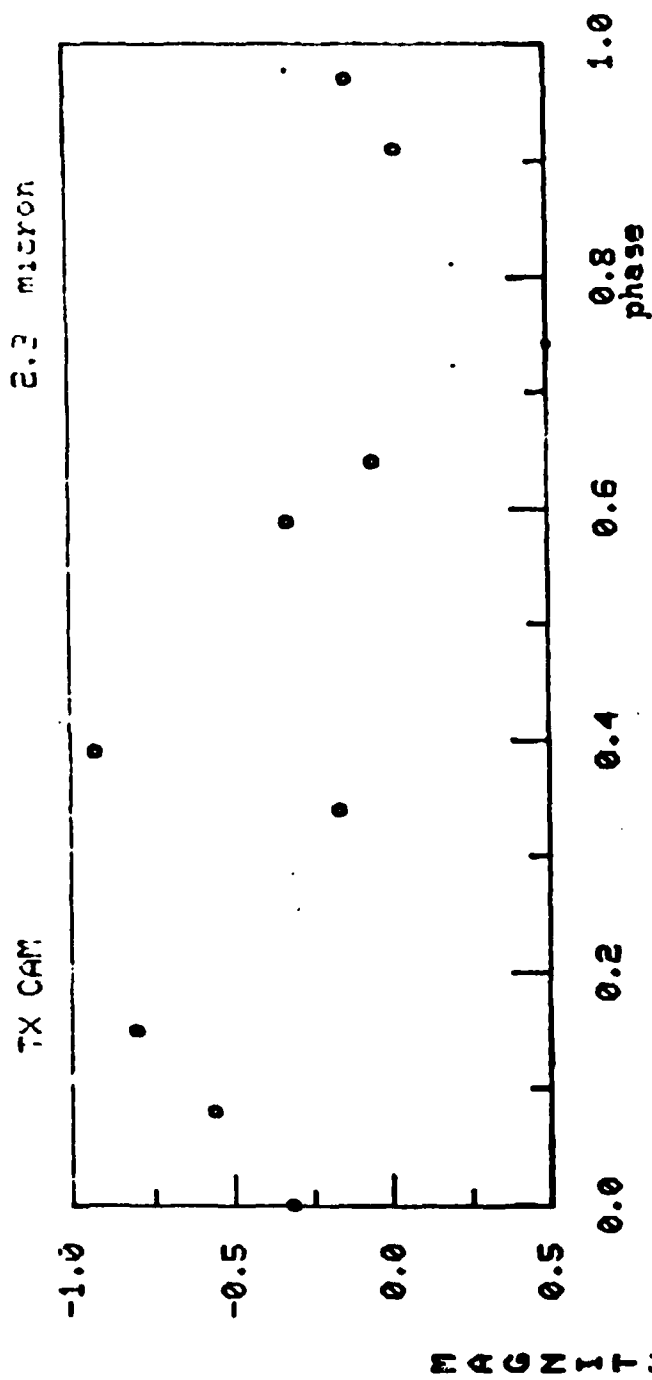
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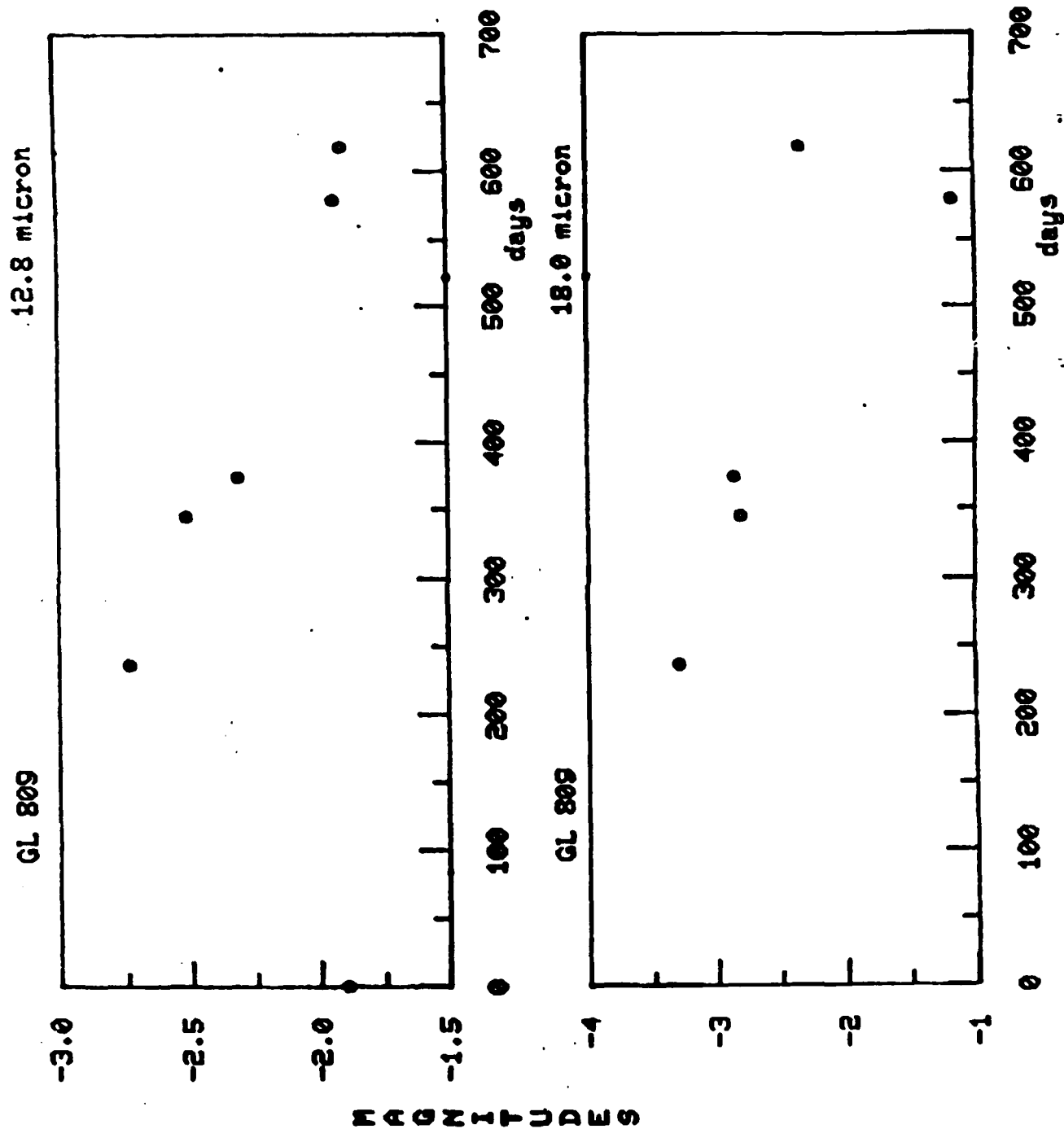


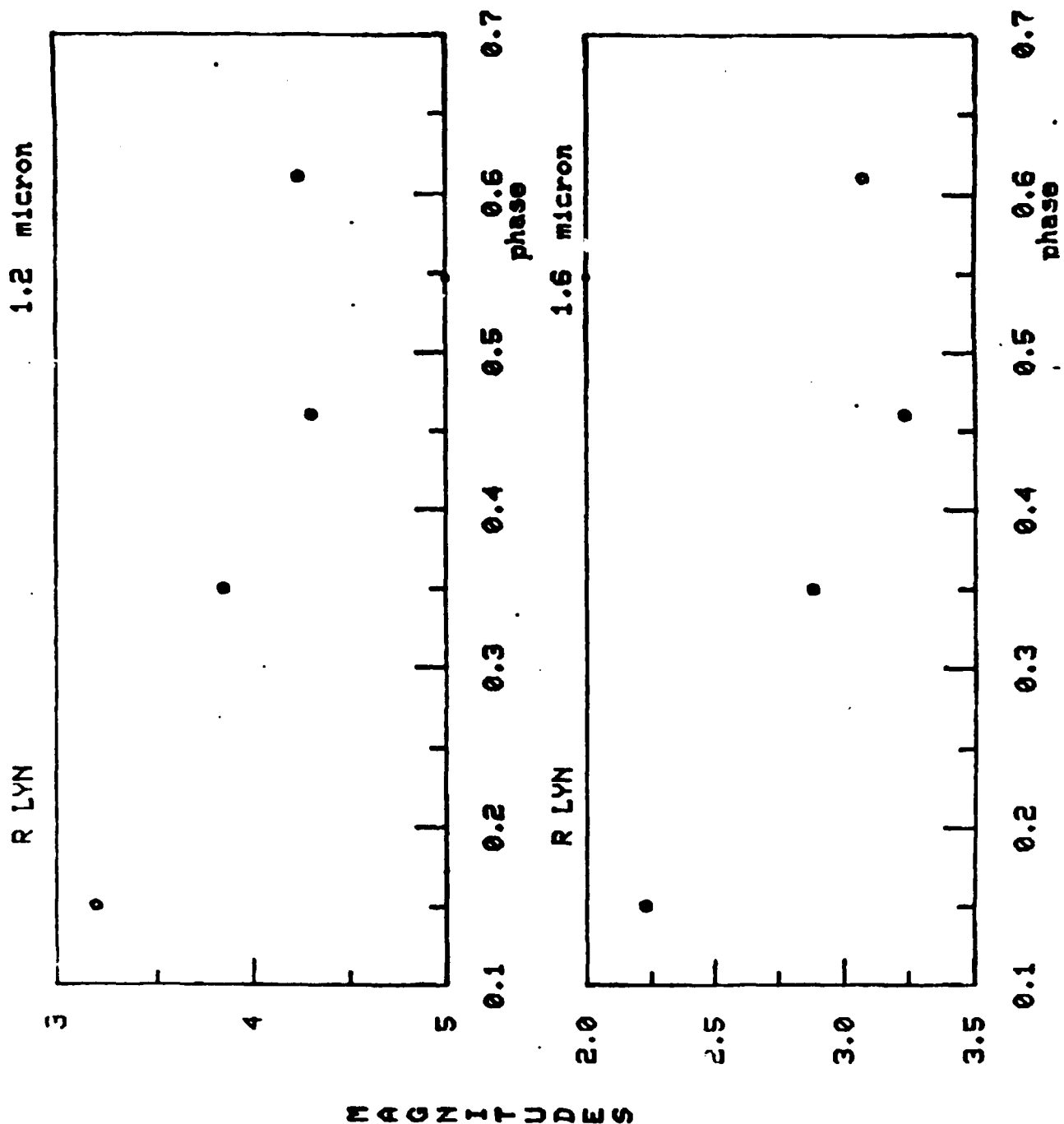


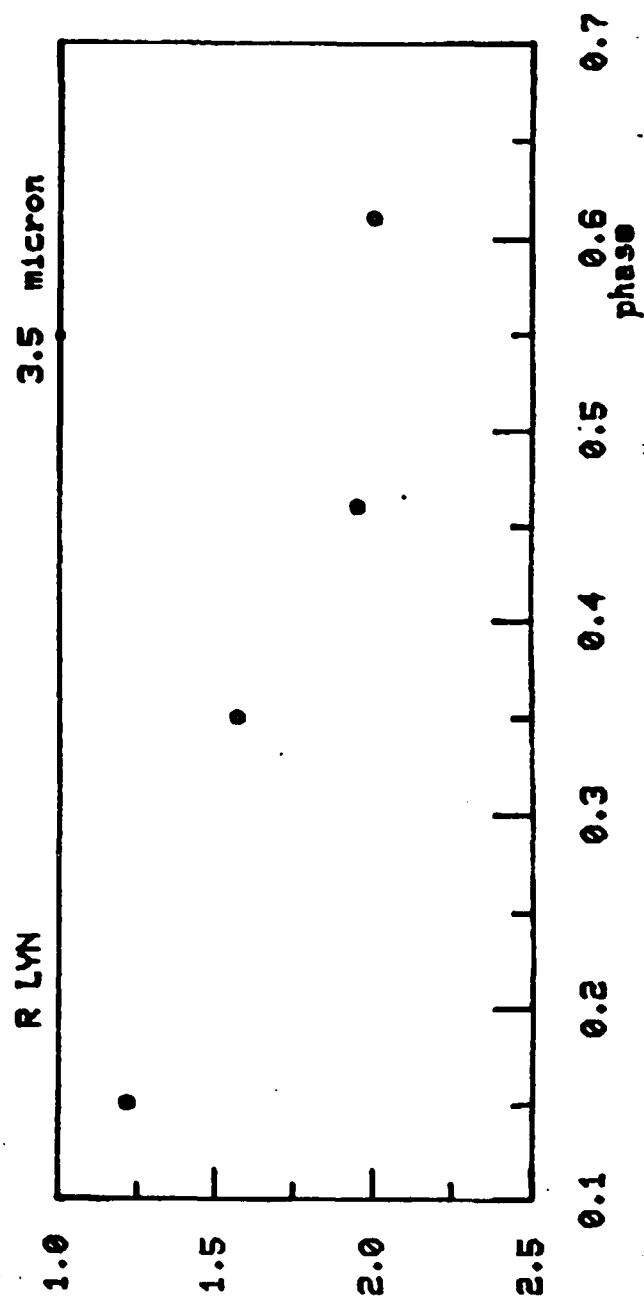
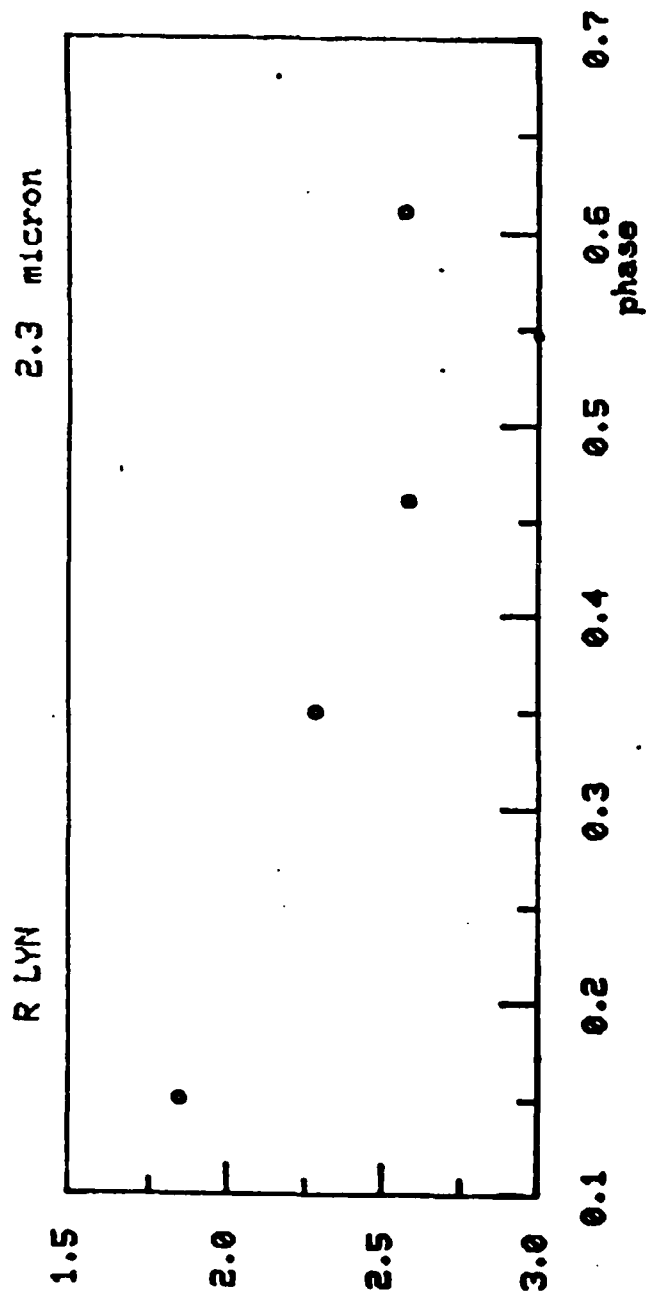


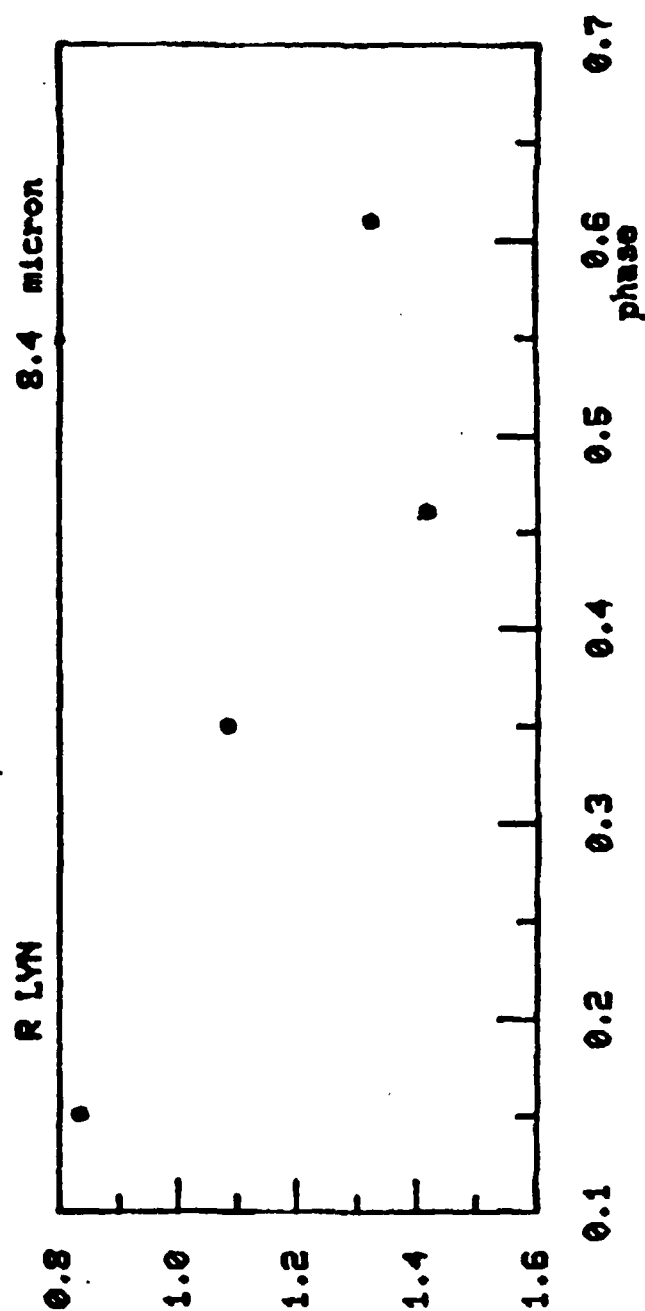
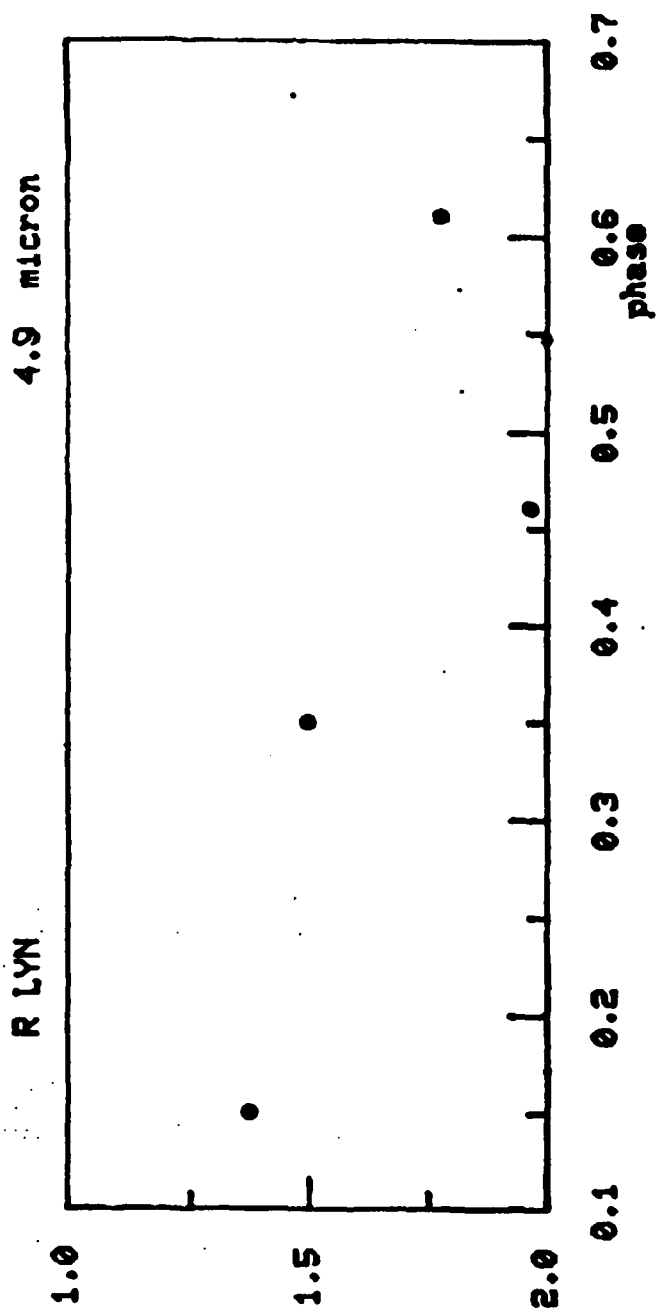


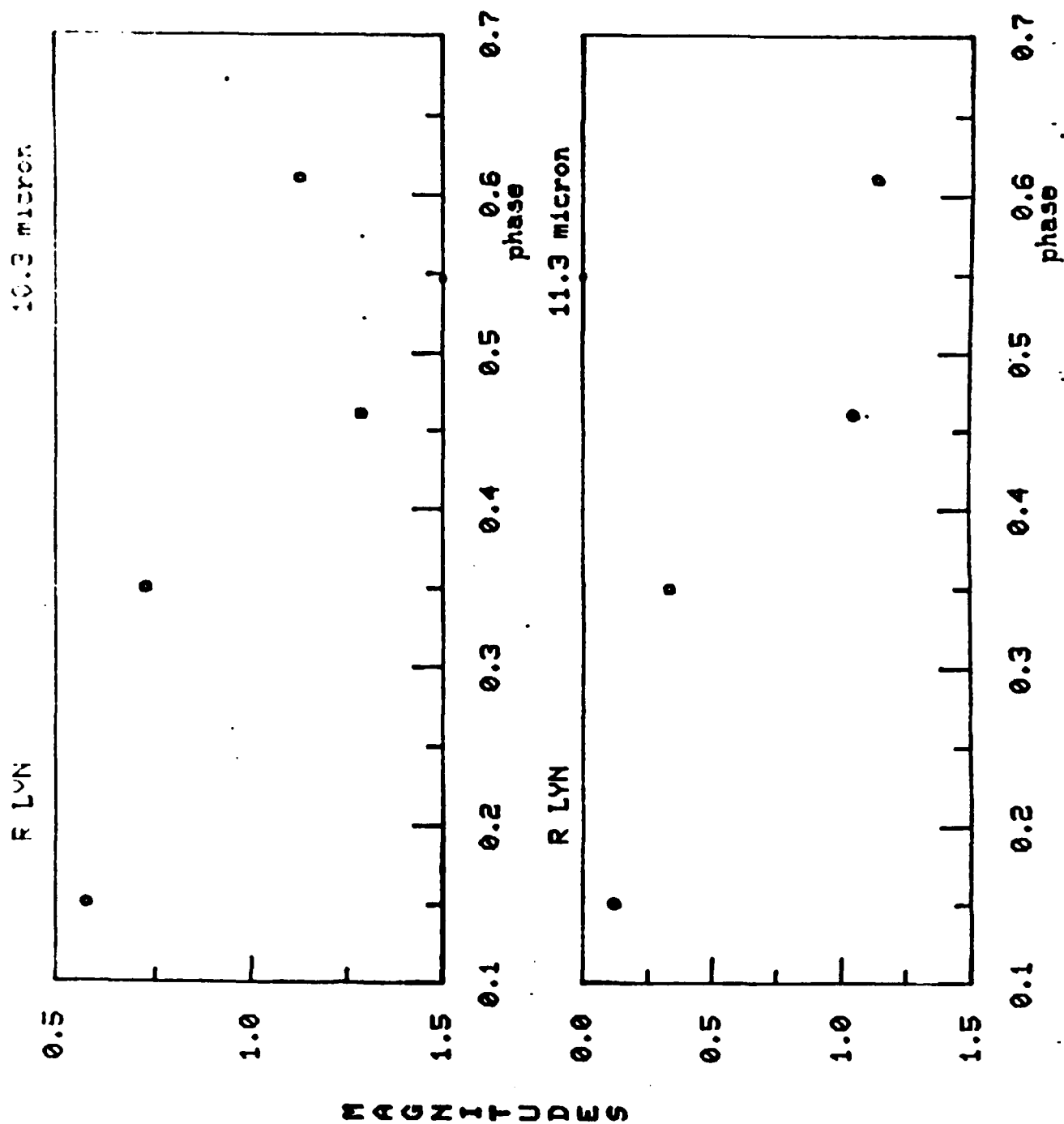


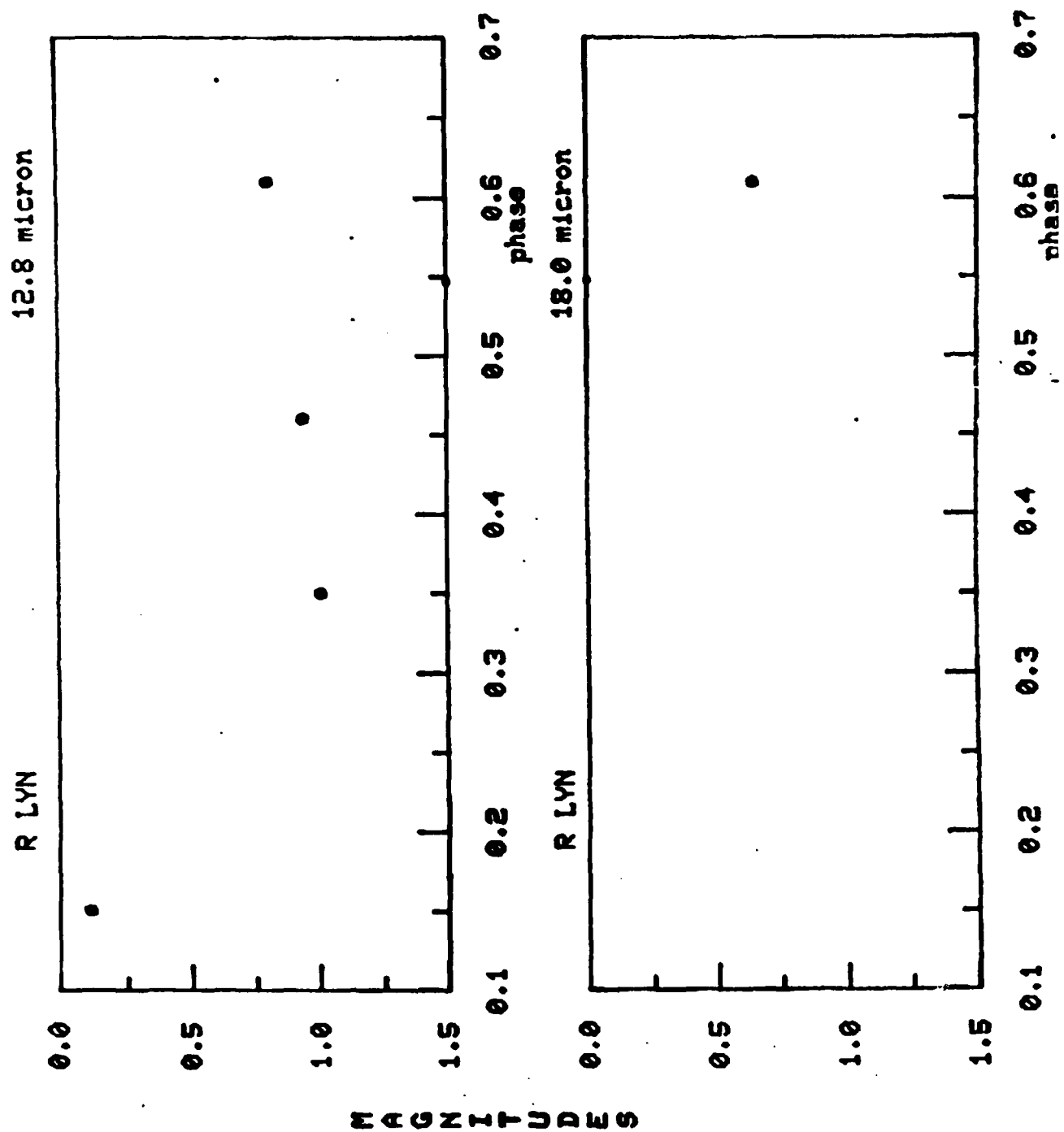












1975

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4.0

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m<sub>v</sub>

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16.0

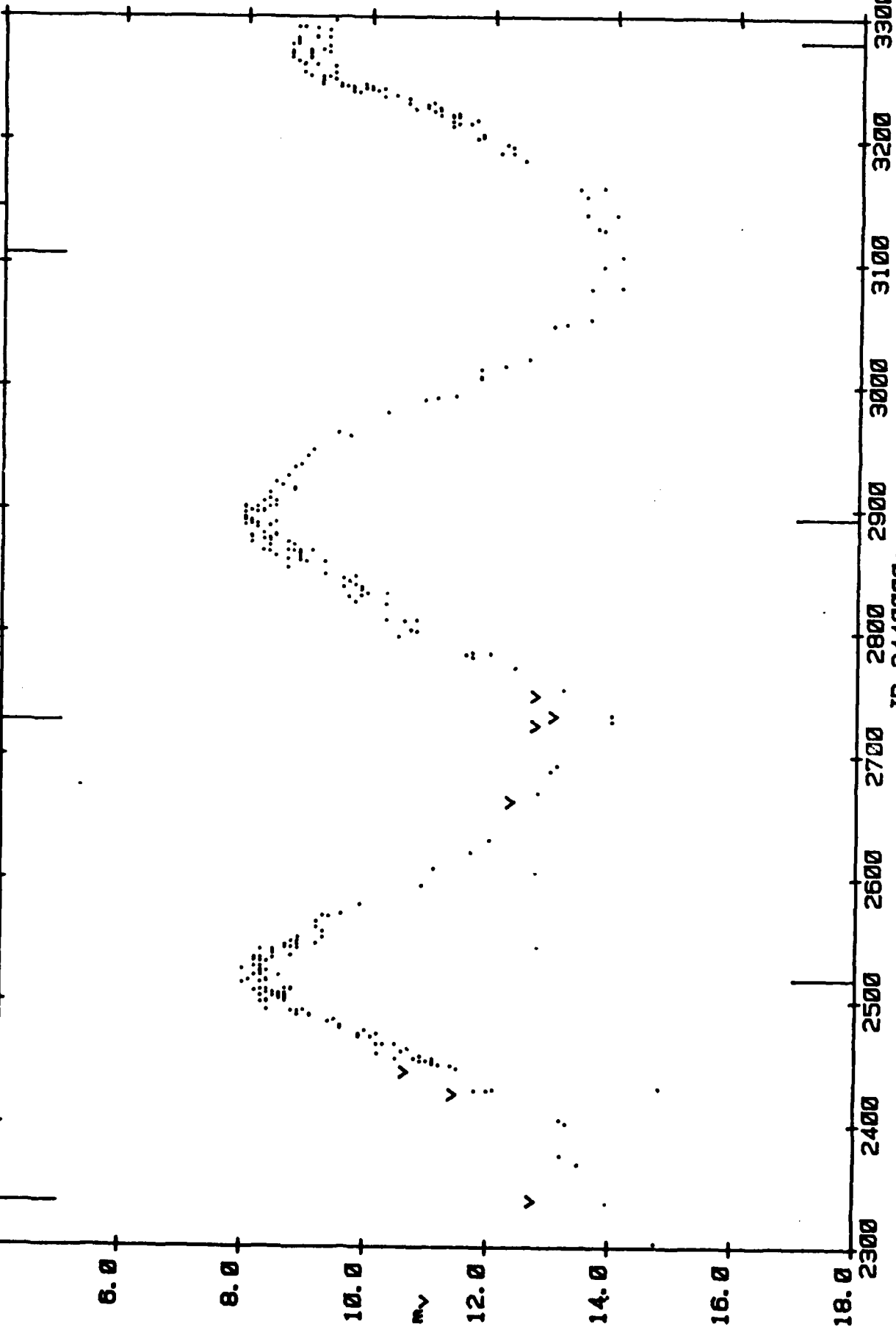
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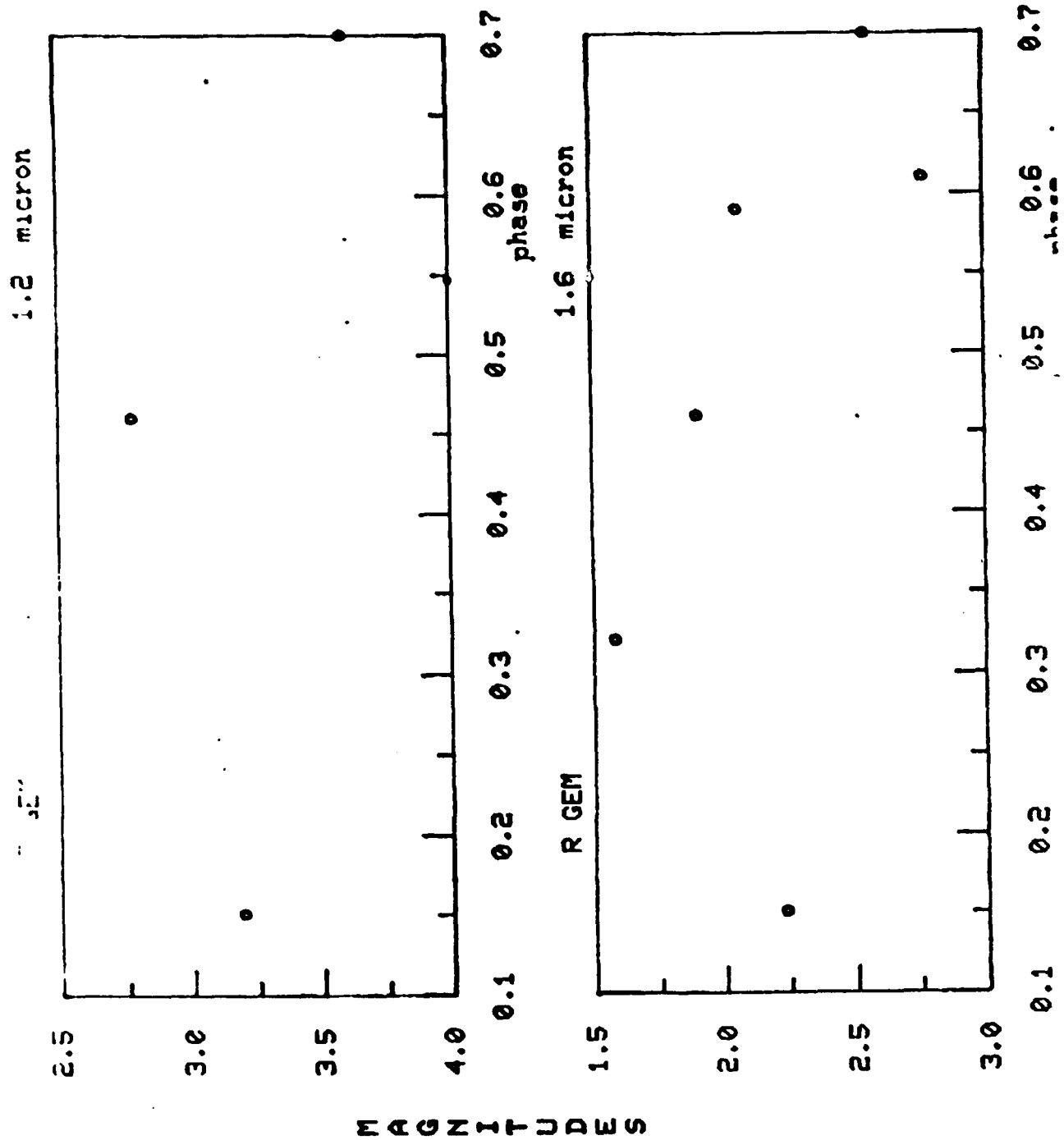
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0653+55 R LYN

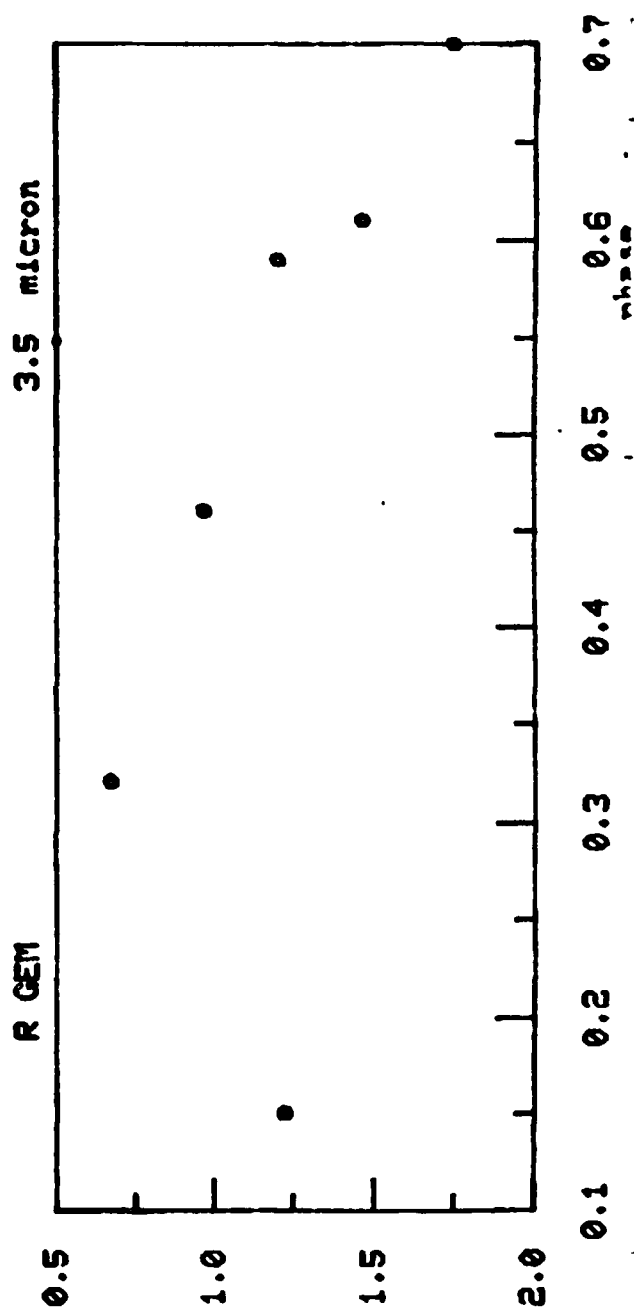
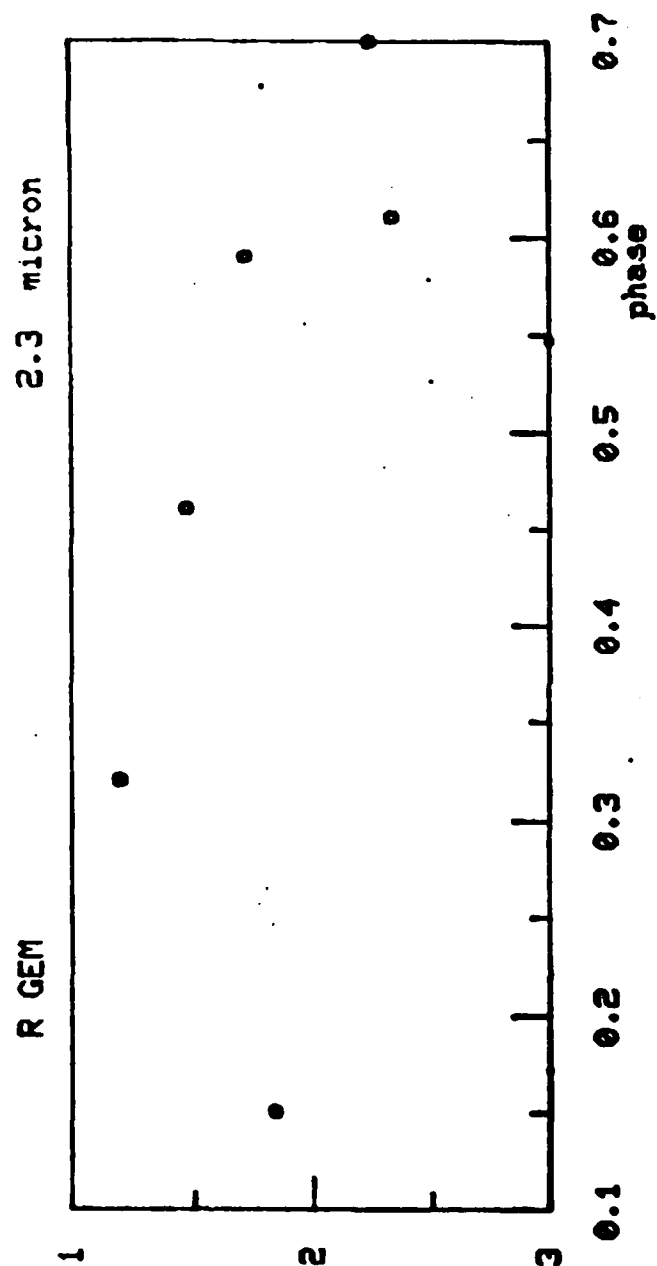
JD 2440000+

MIRA

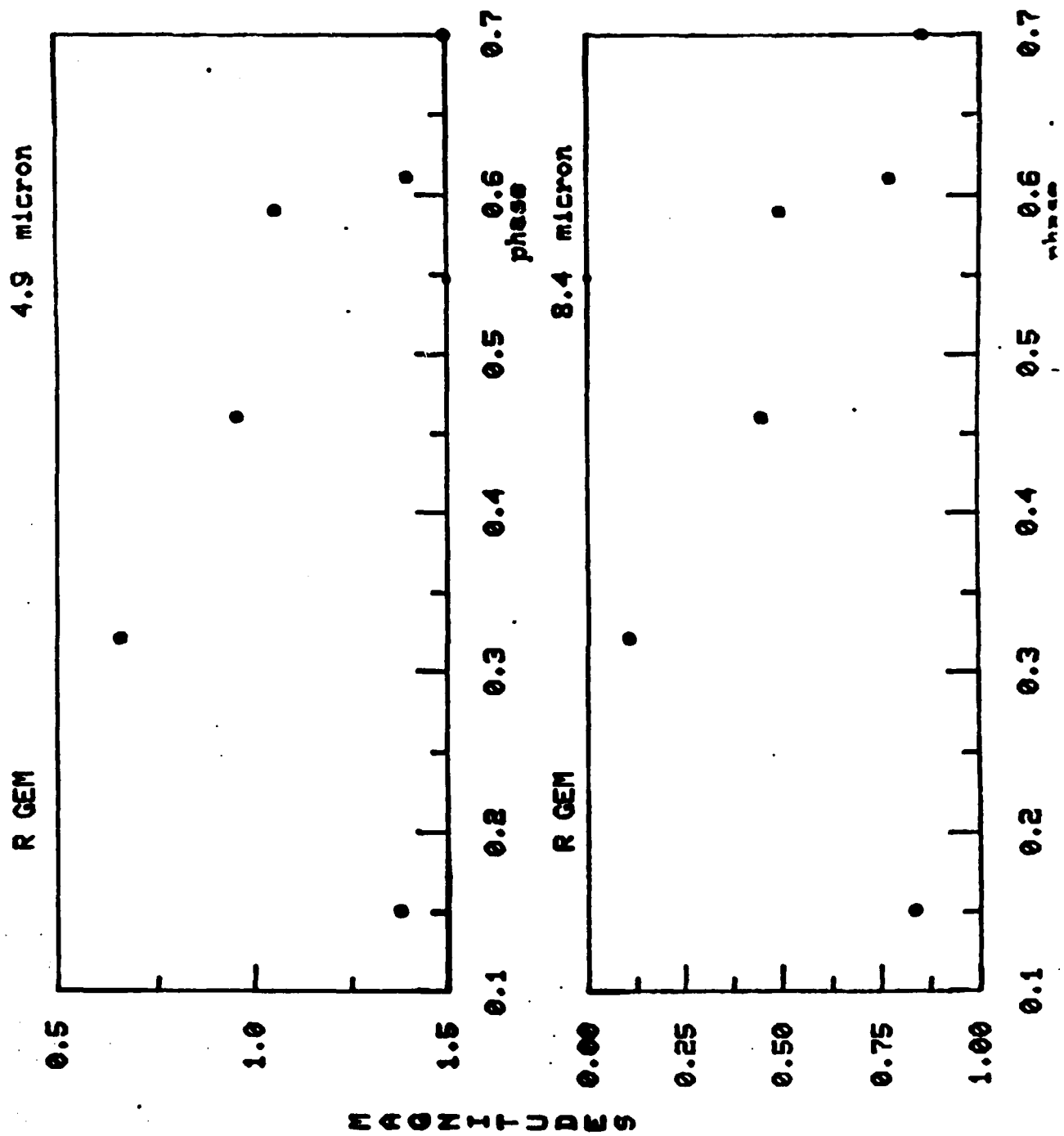


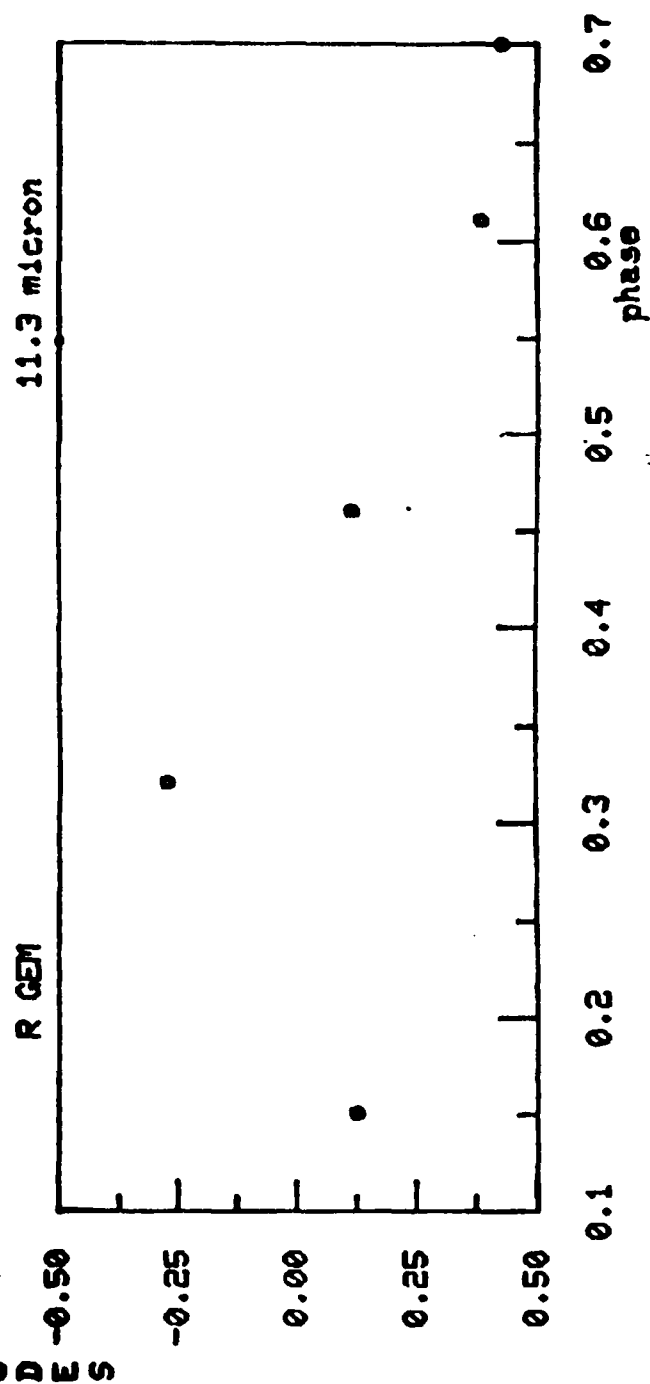
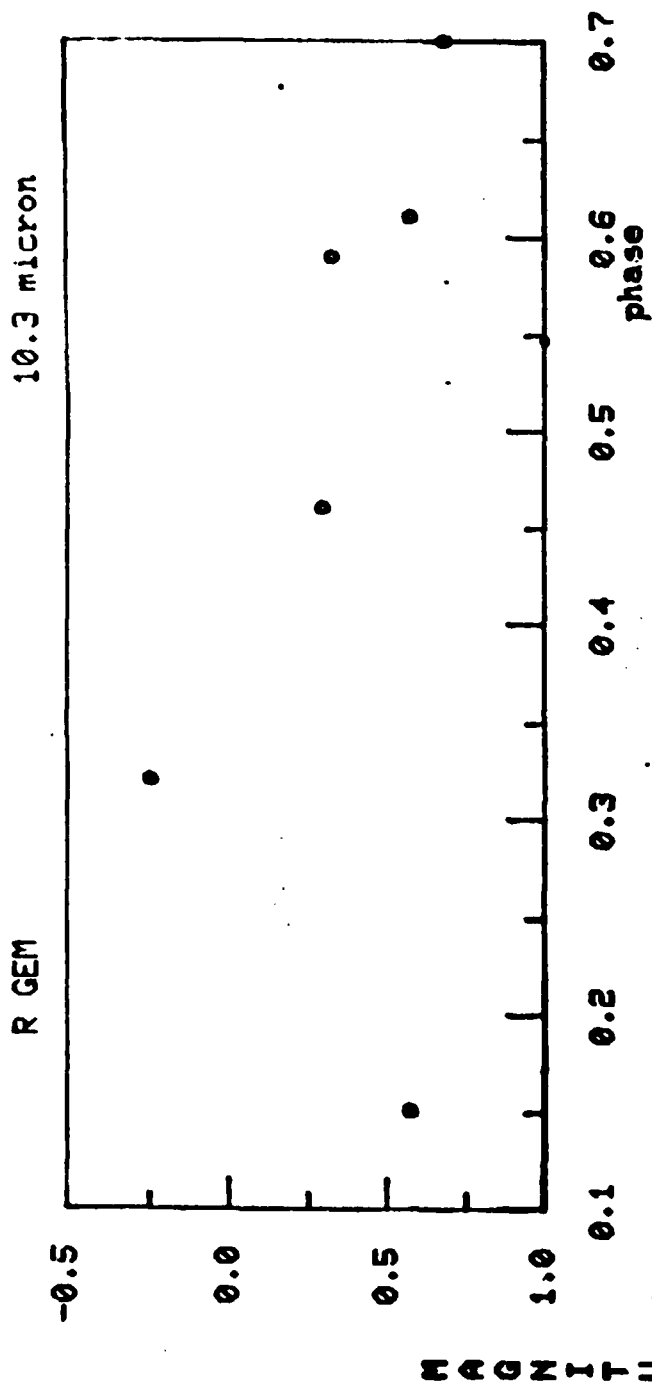


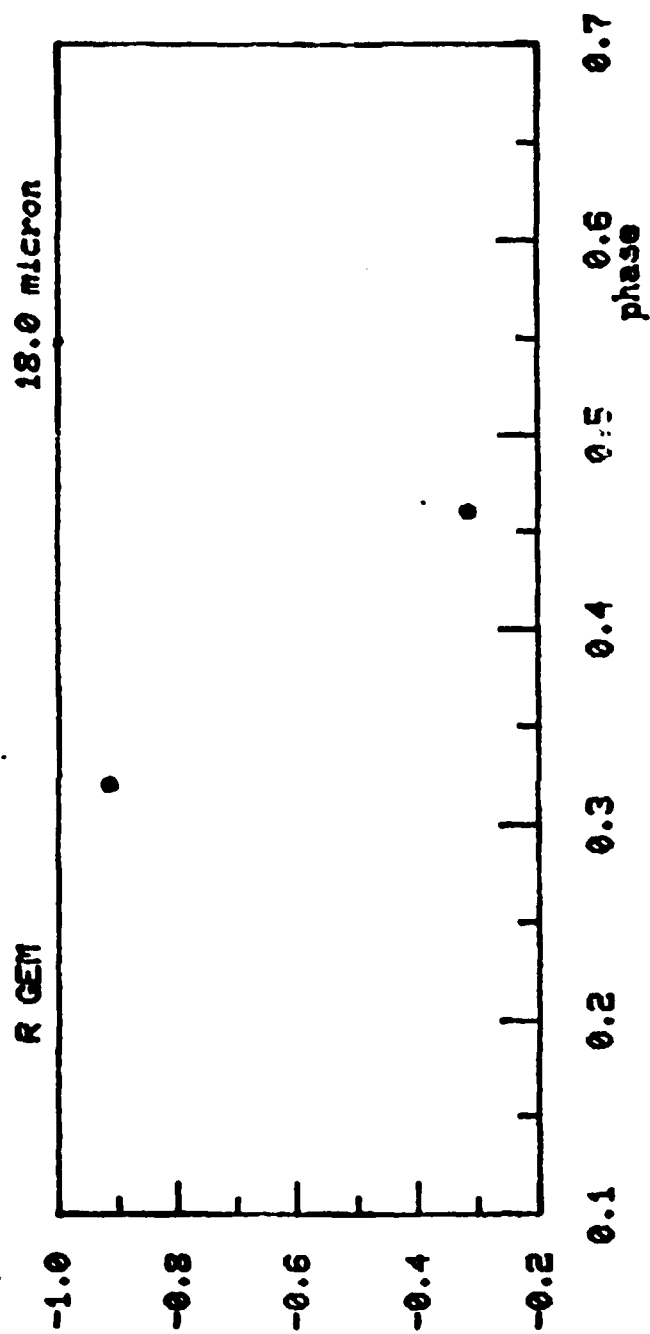
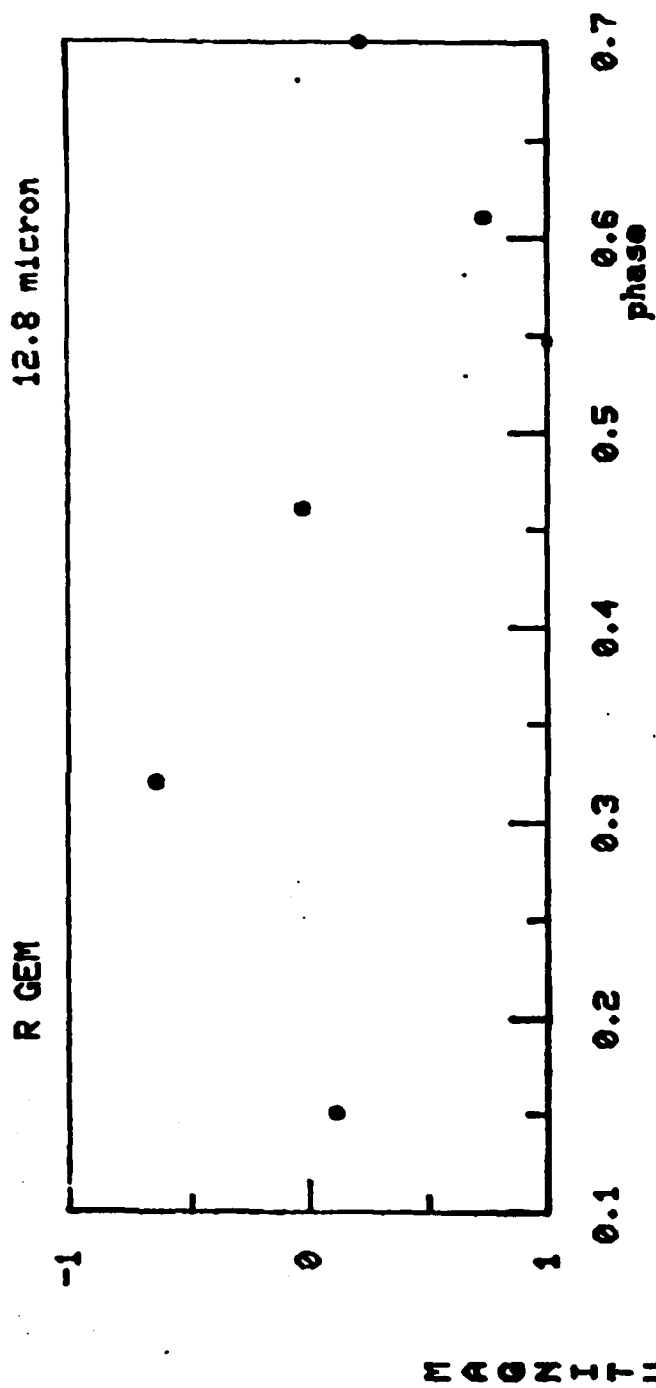


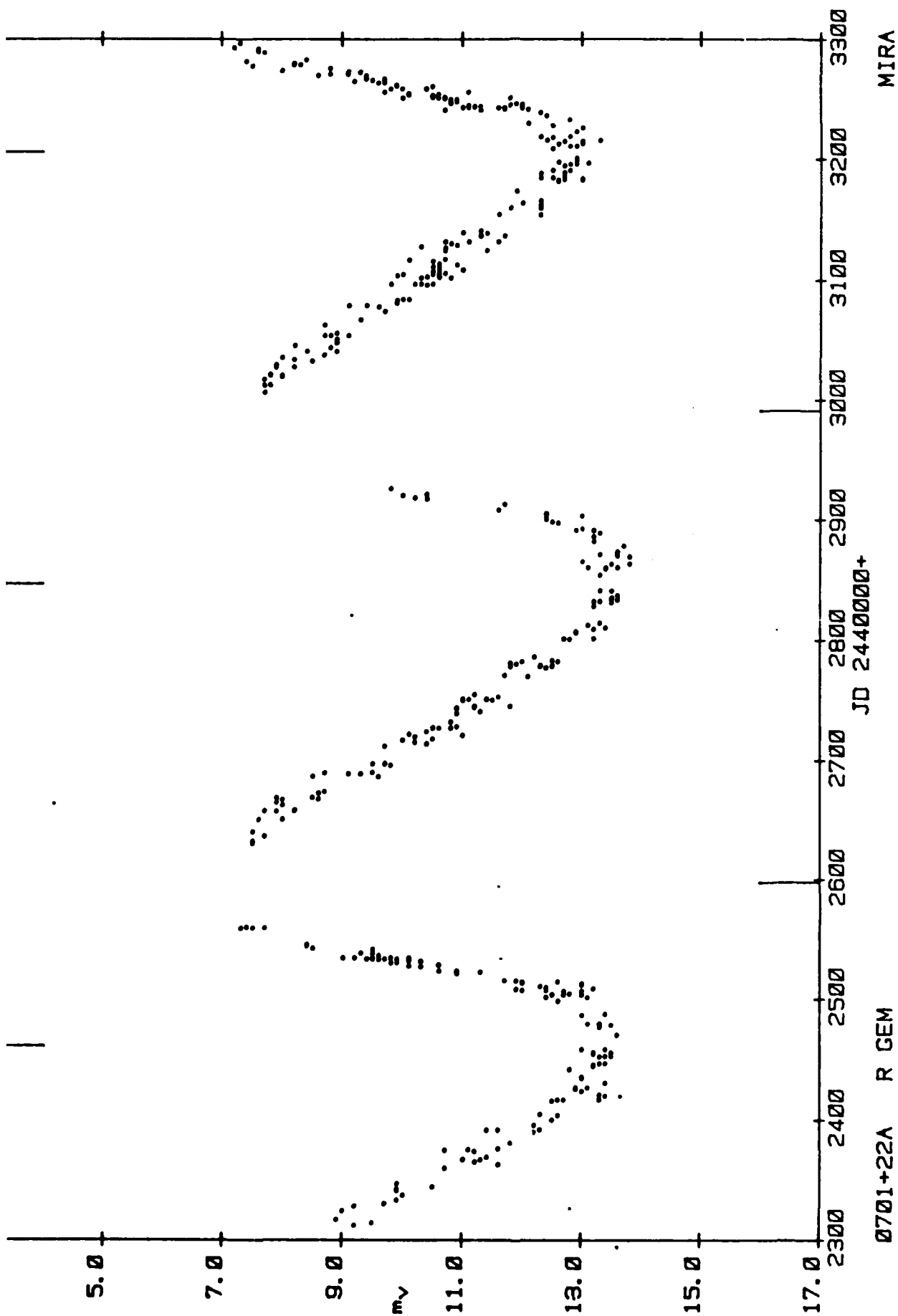


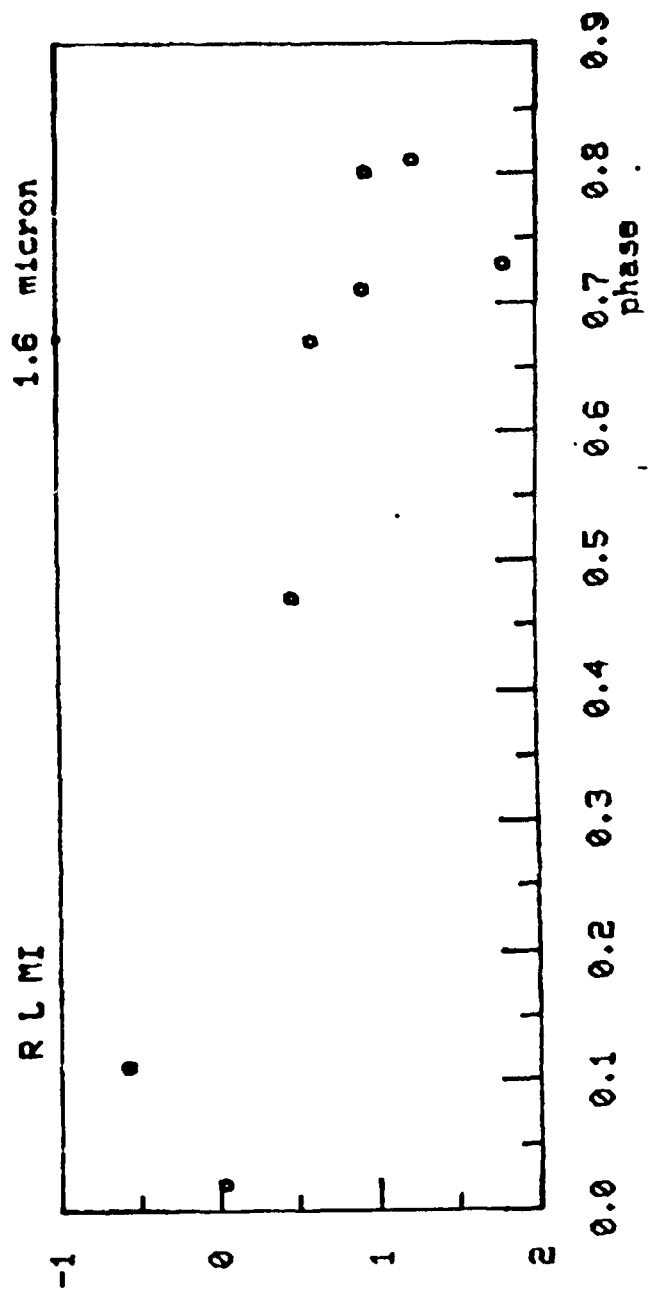
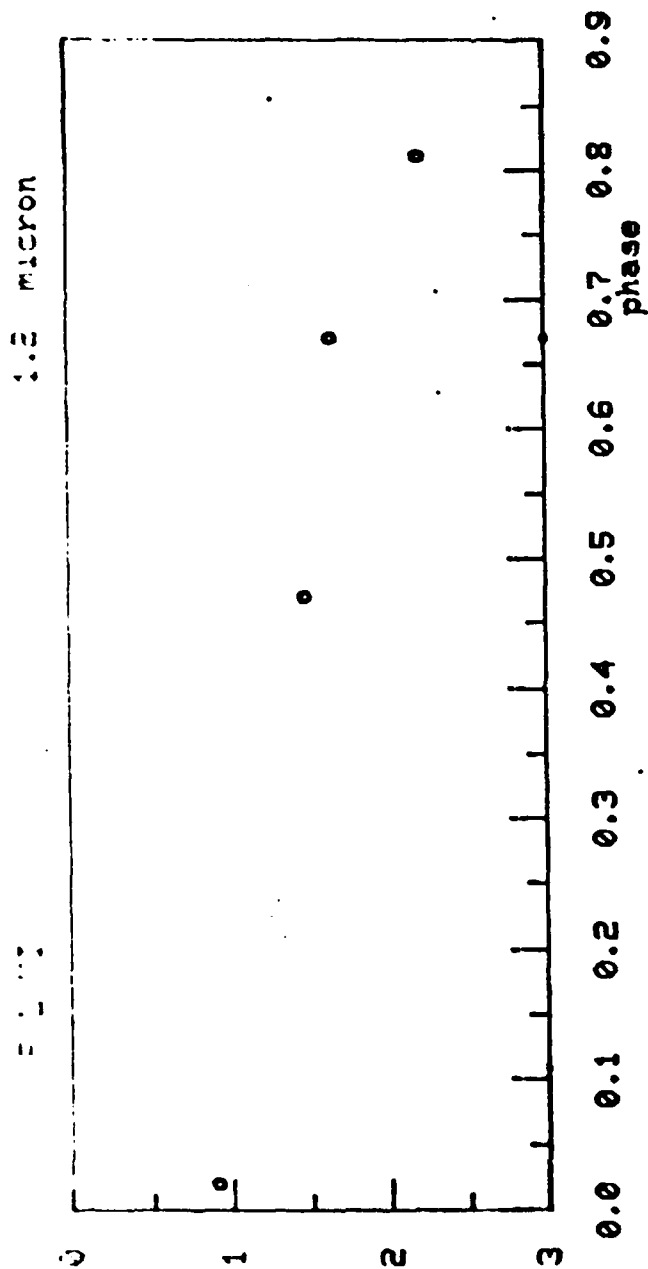
M A G N I T U D E S



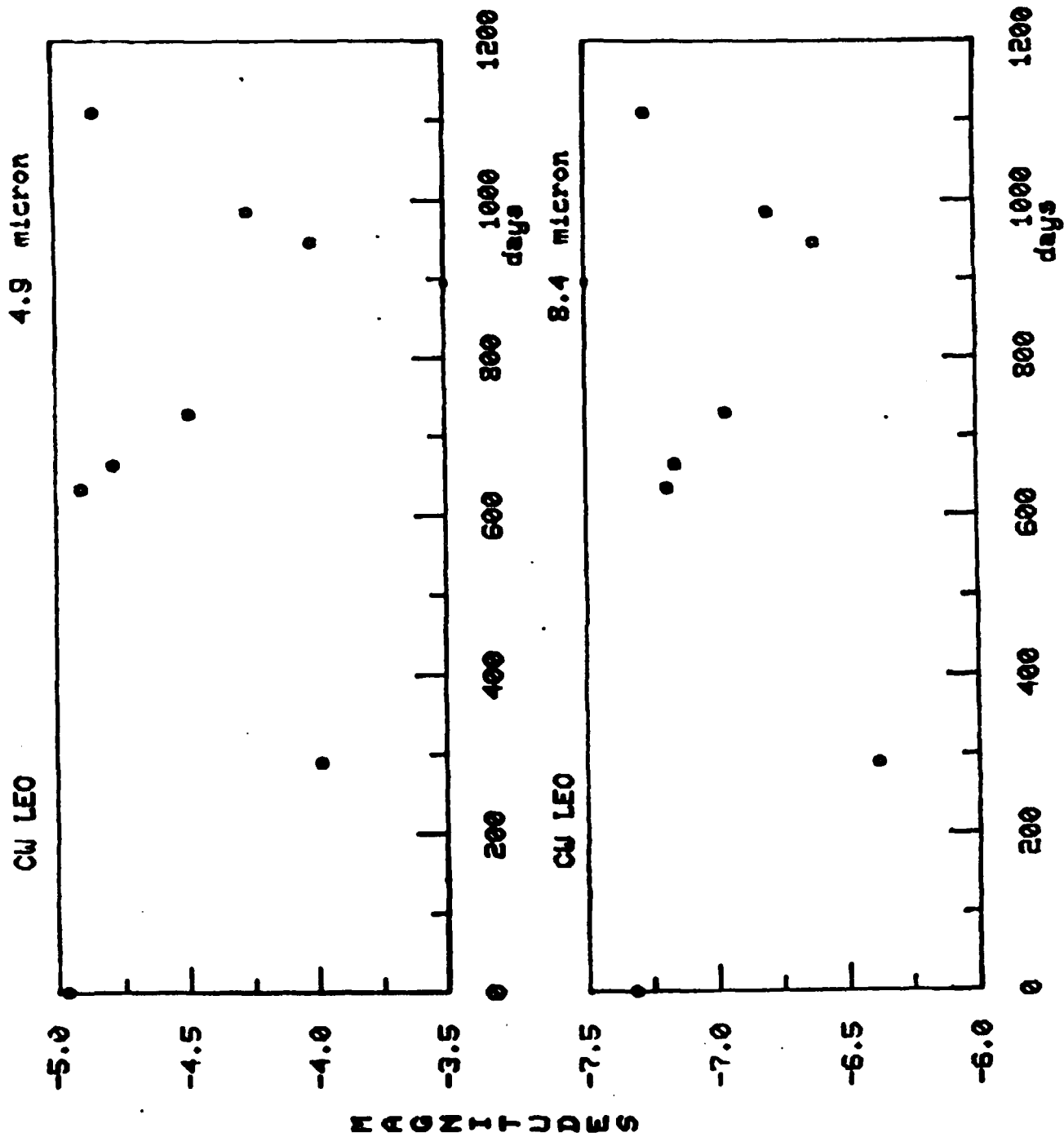


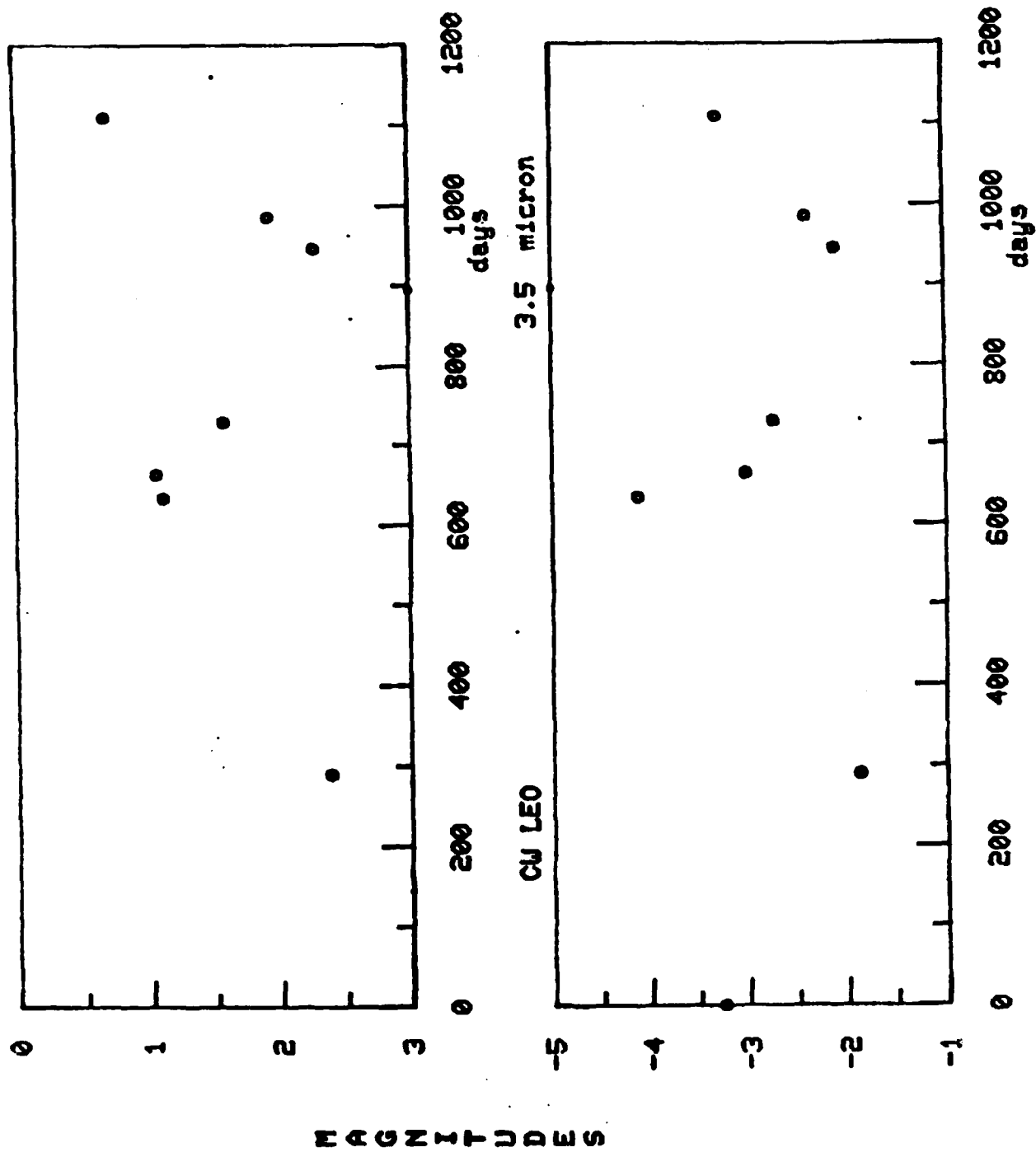




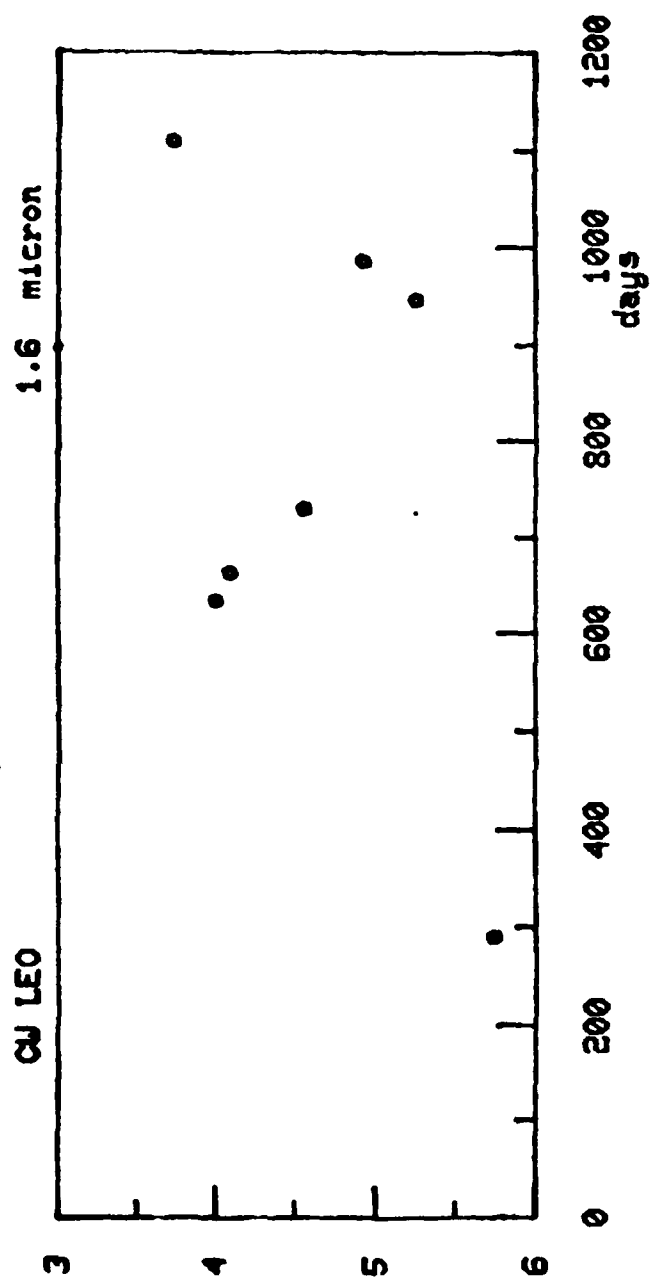
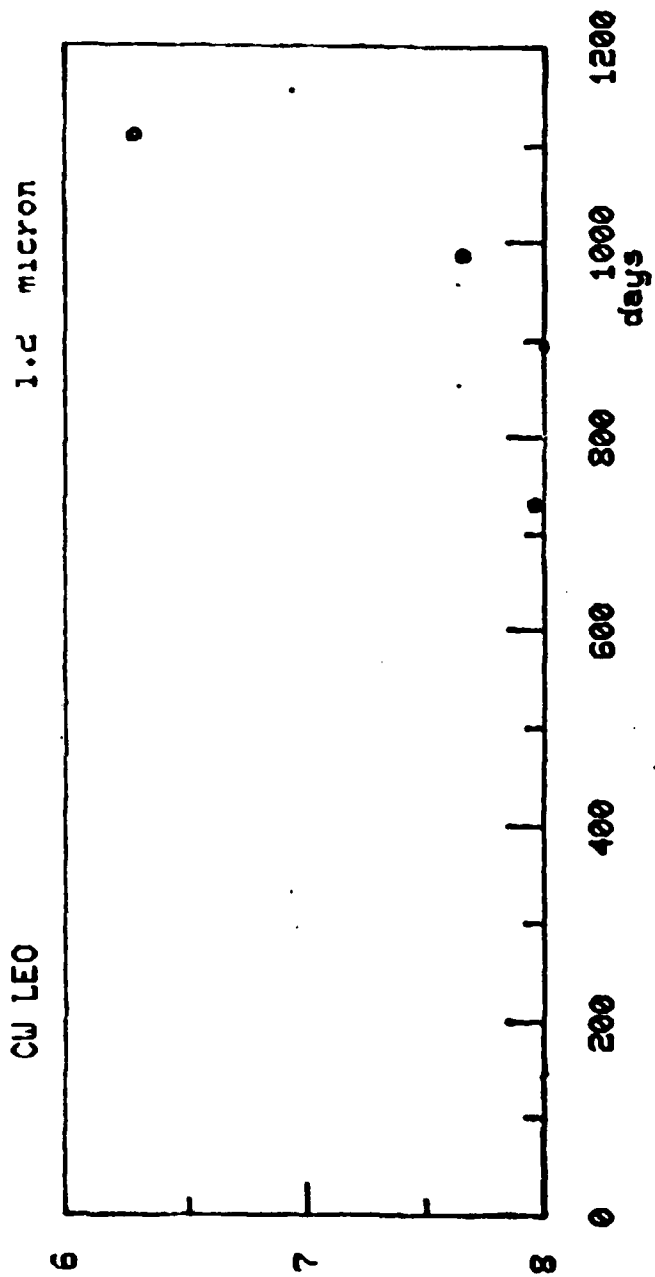


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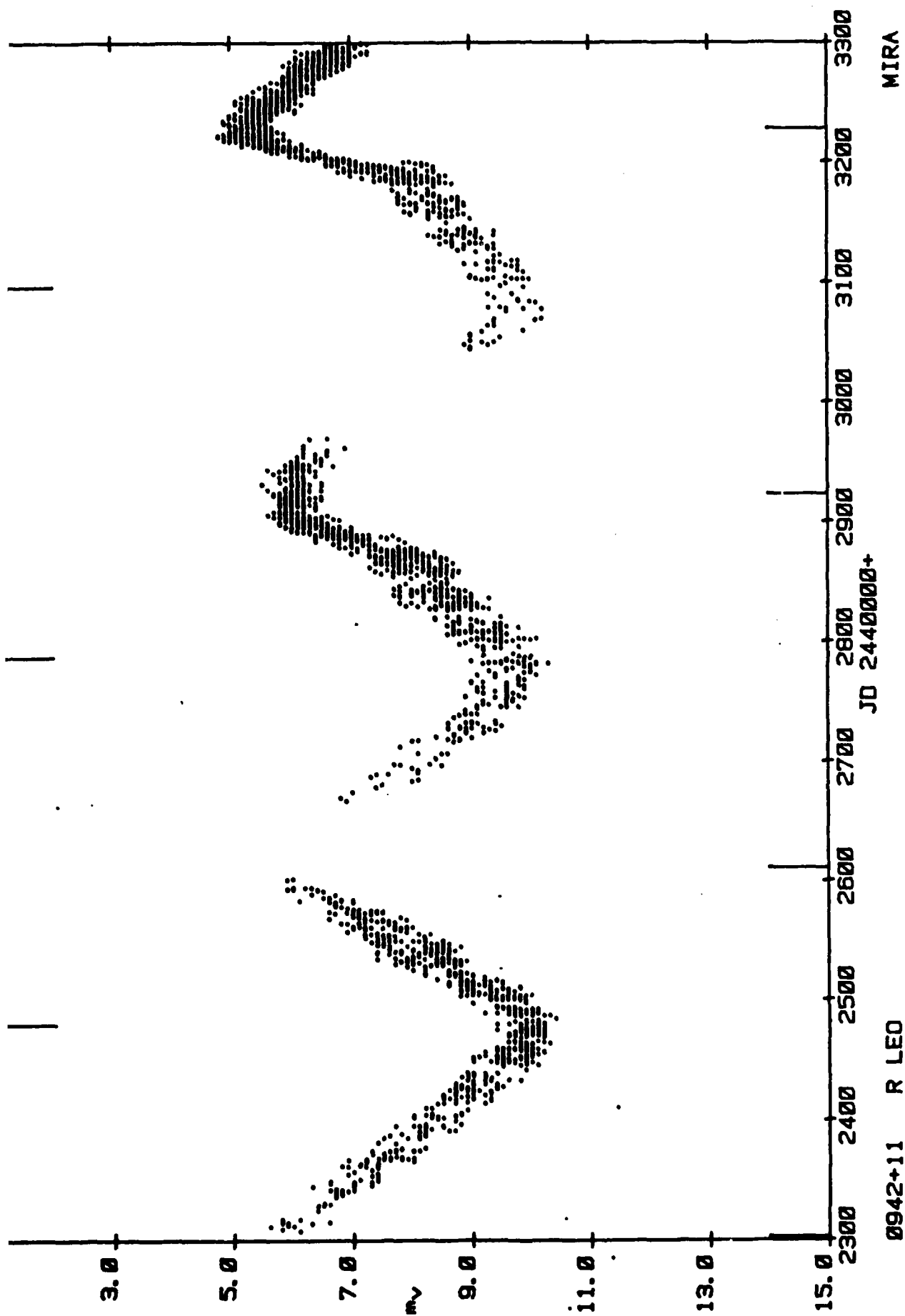


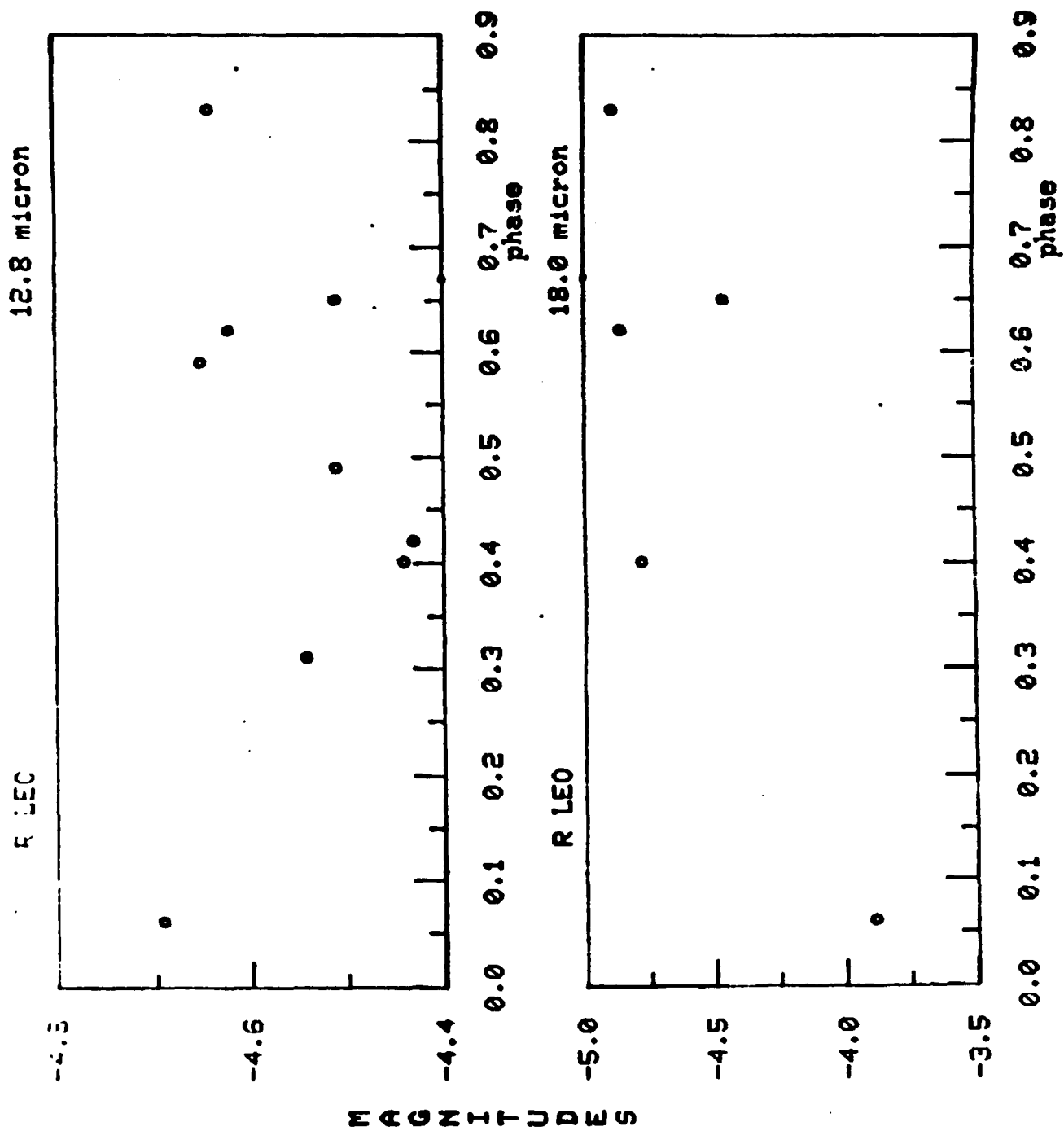


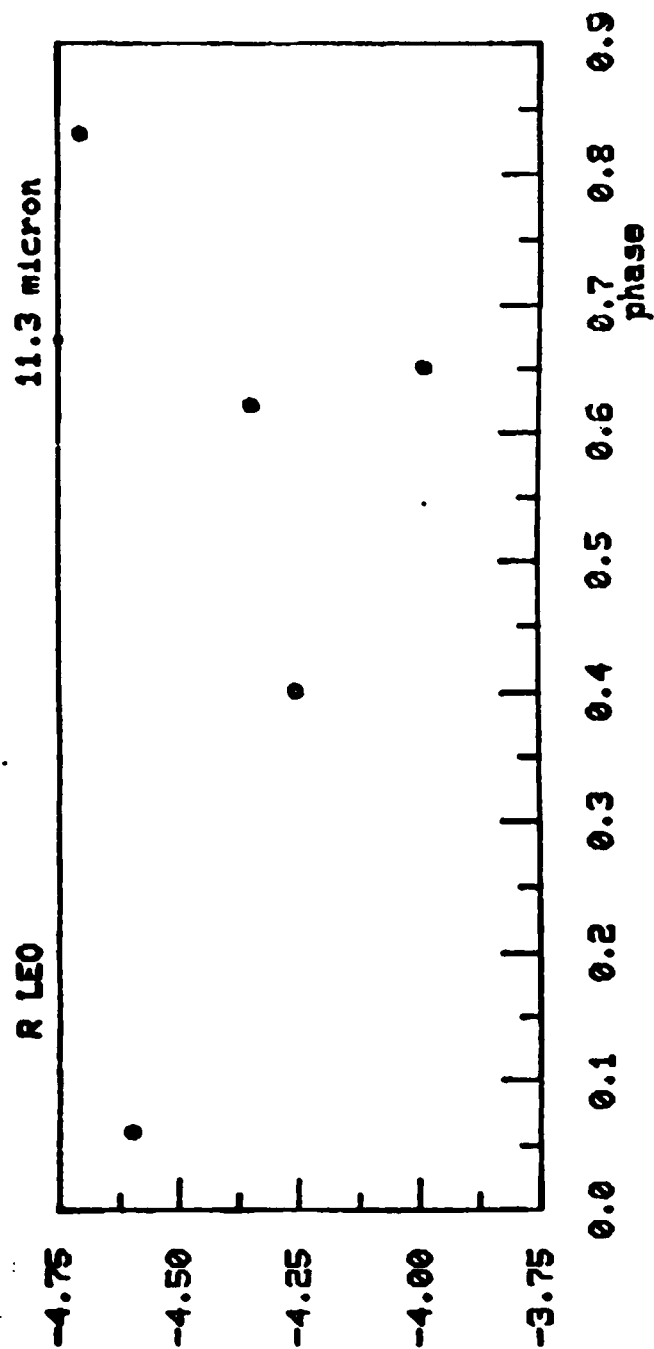
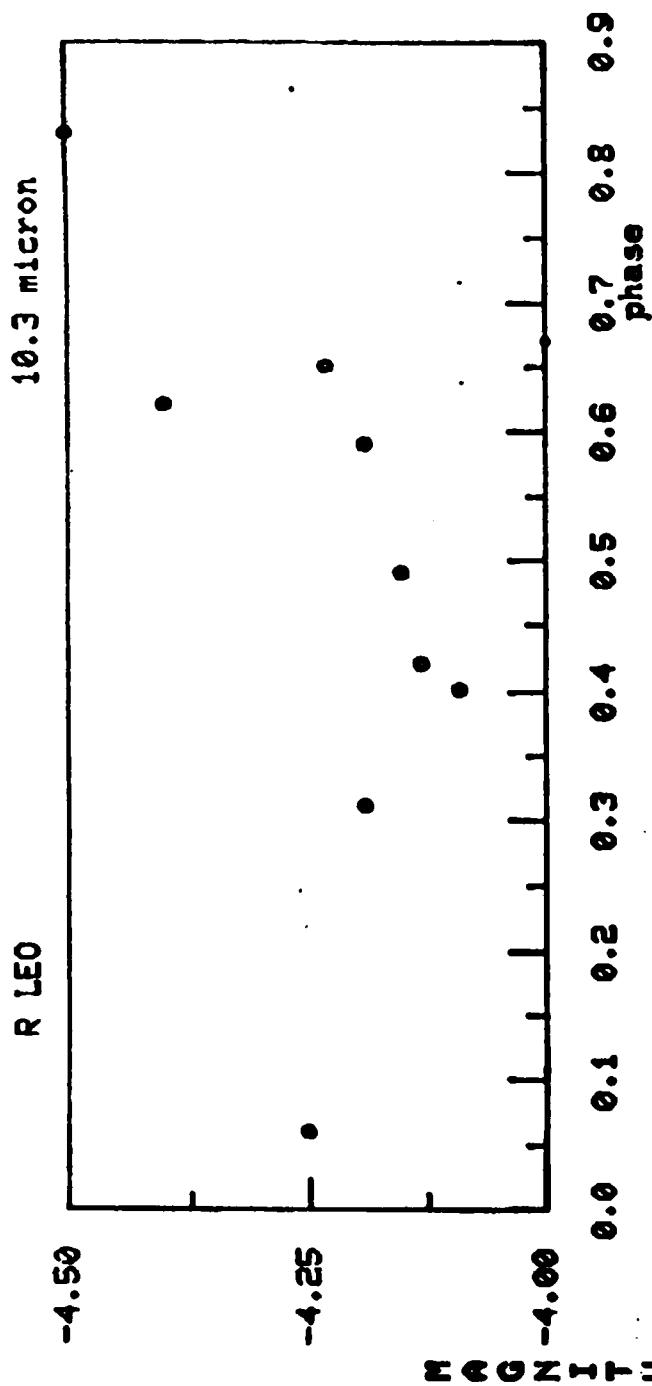


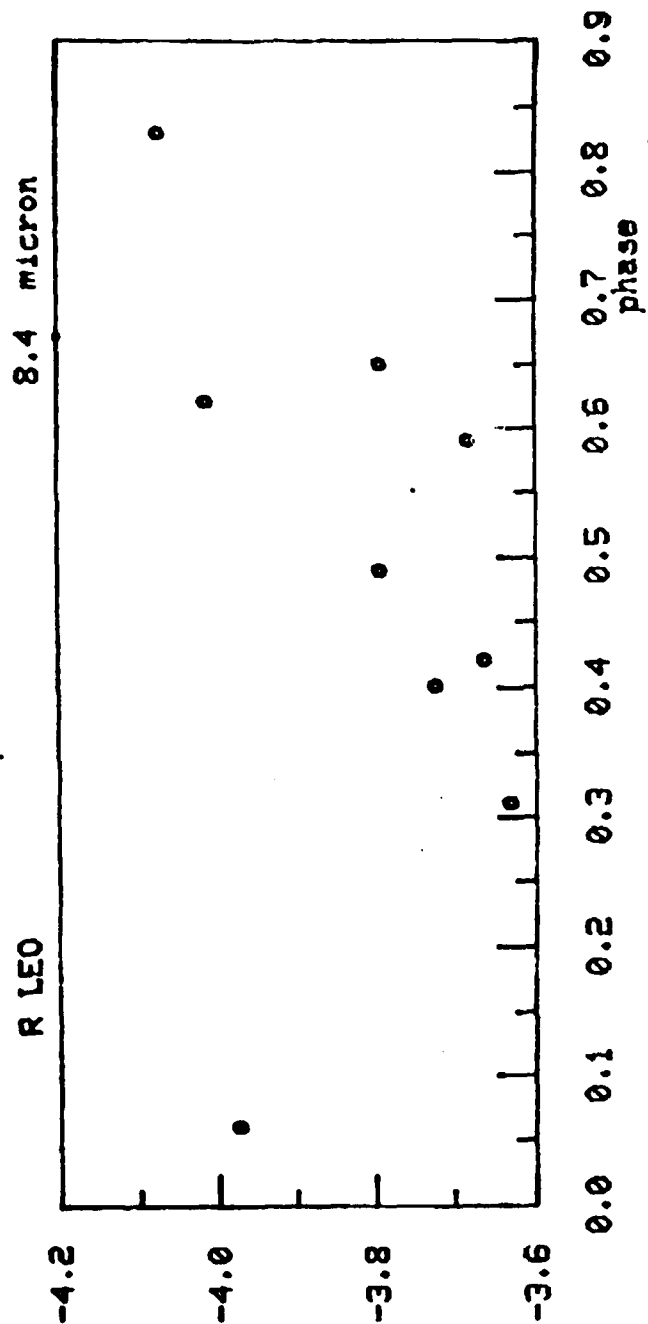
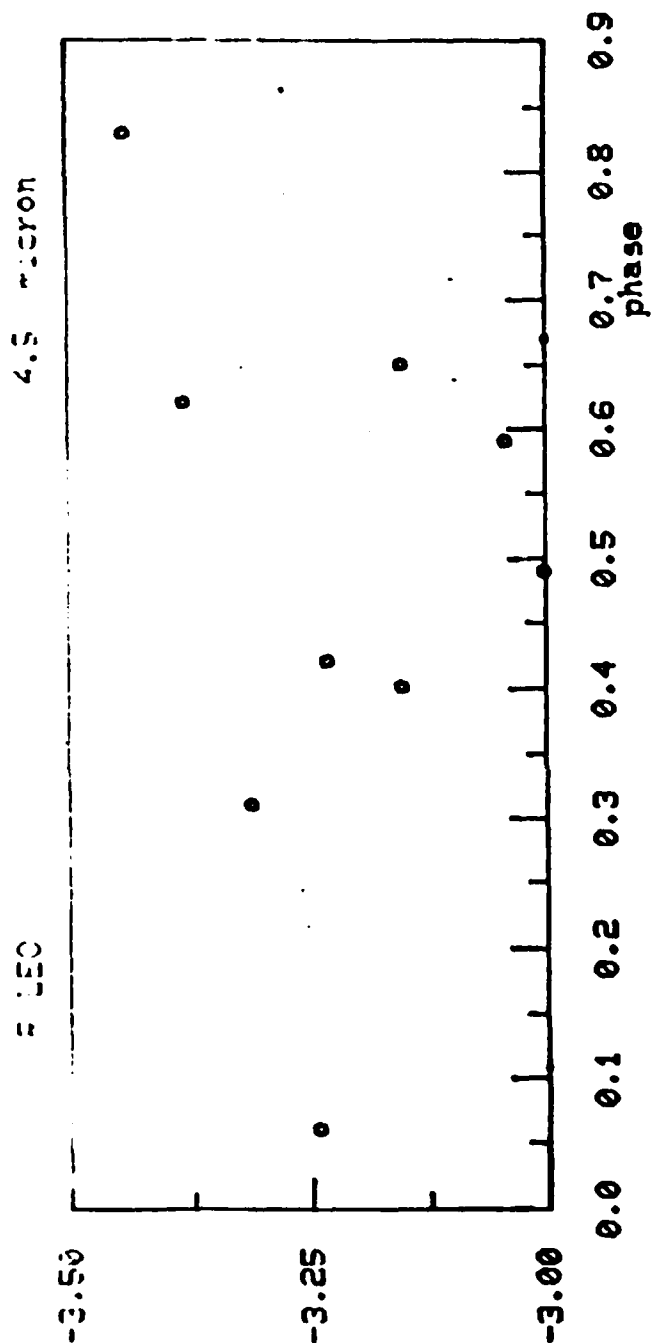


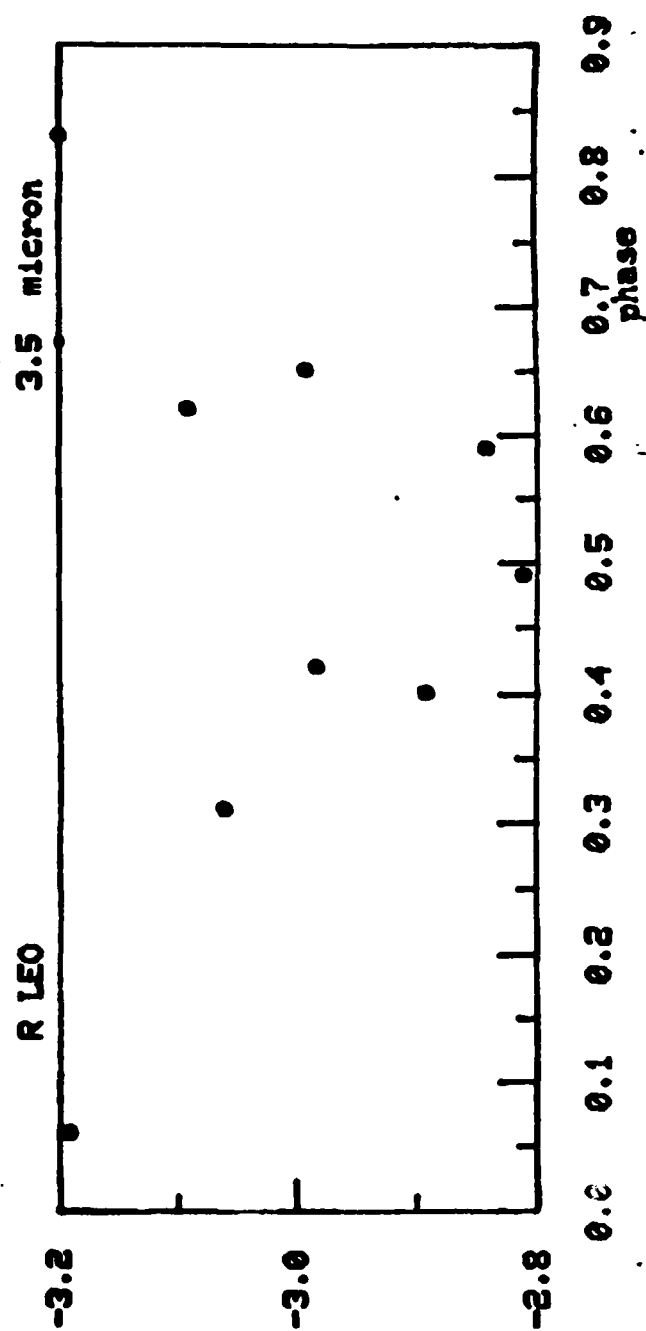
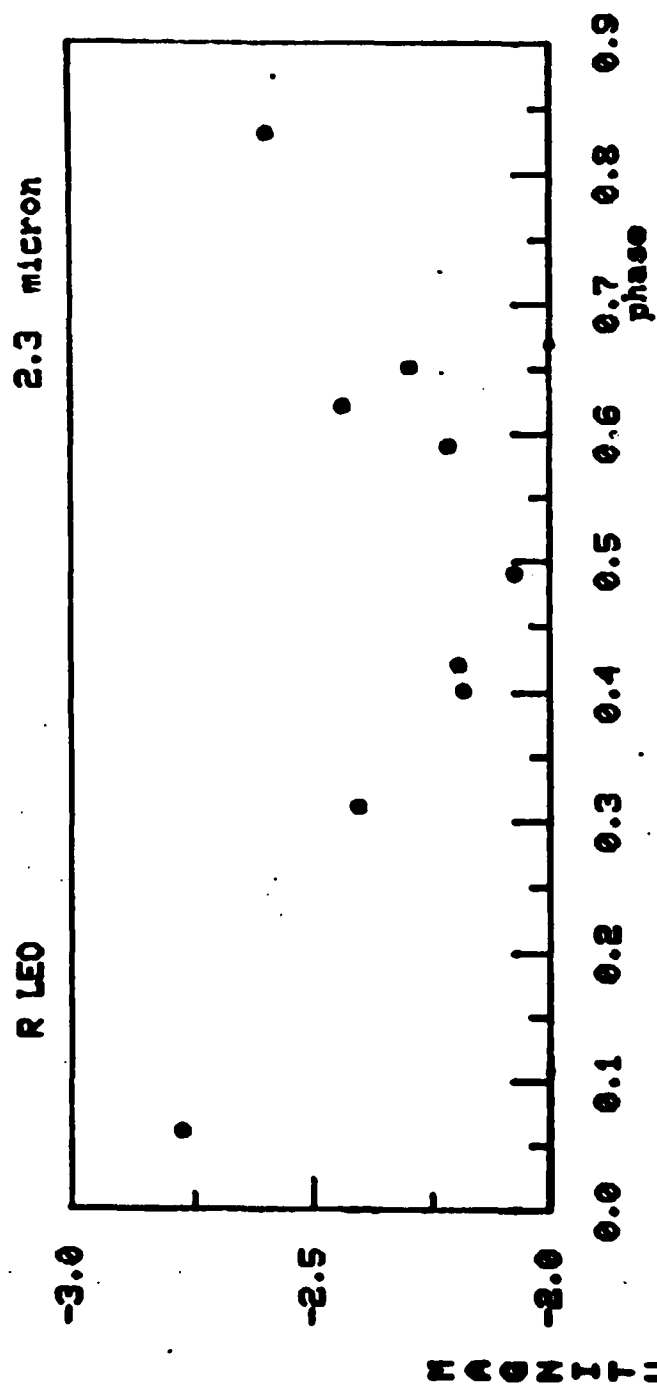
MAGNITUDES

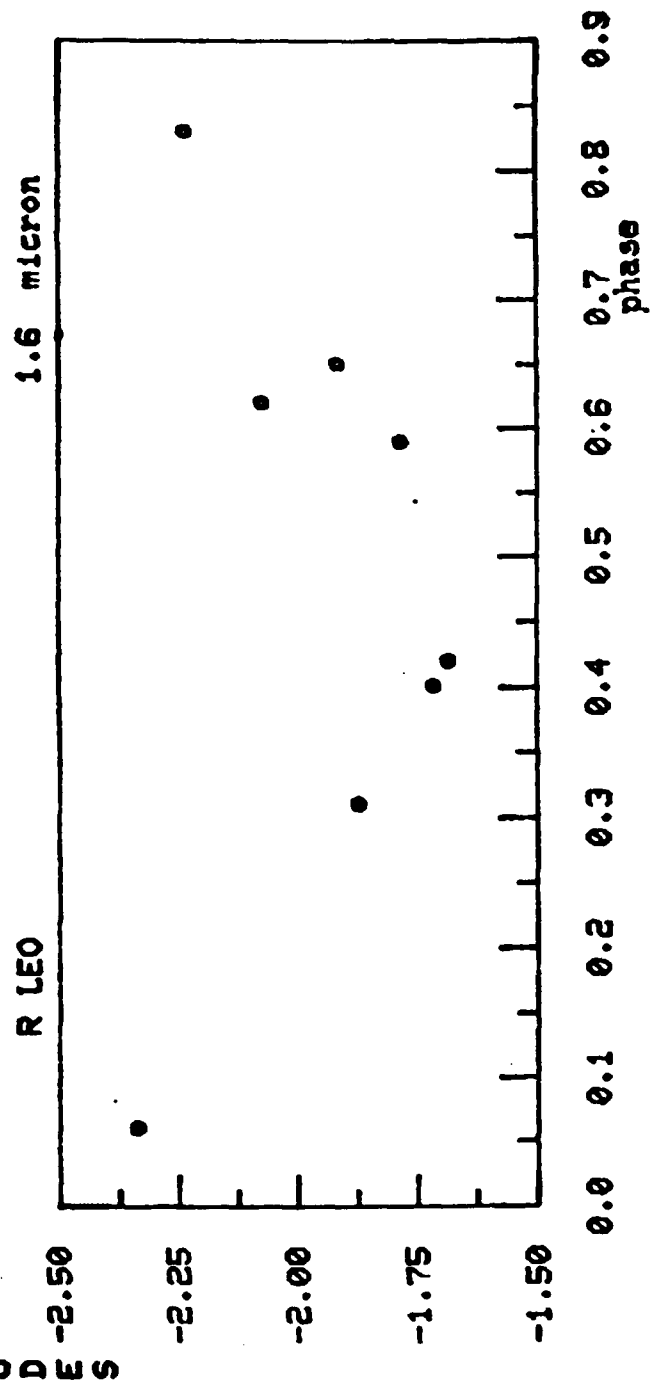
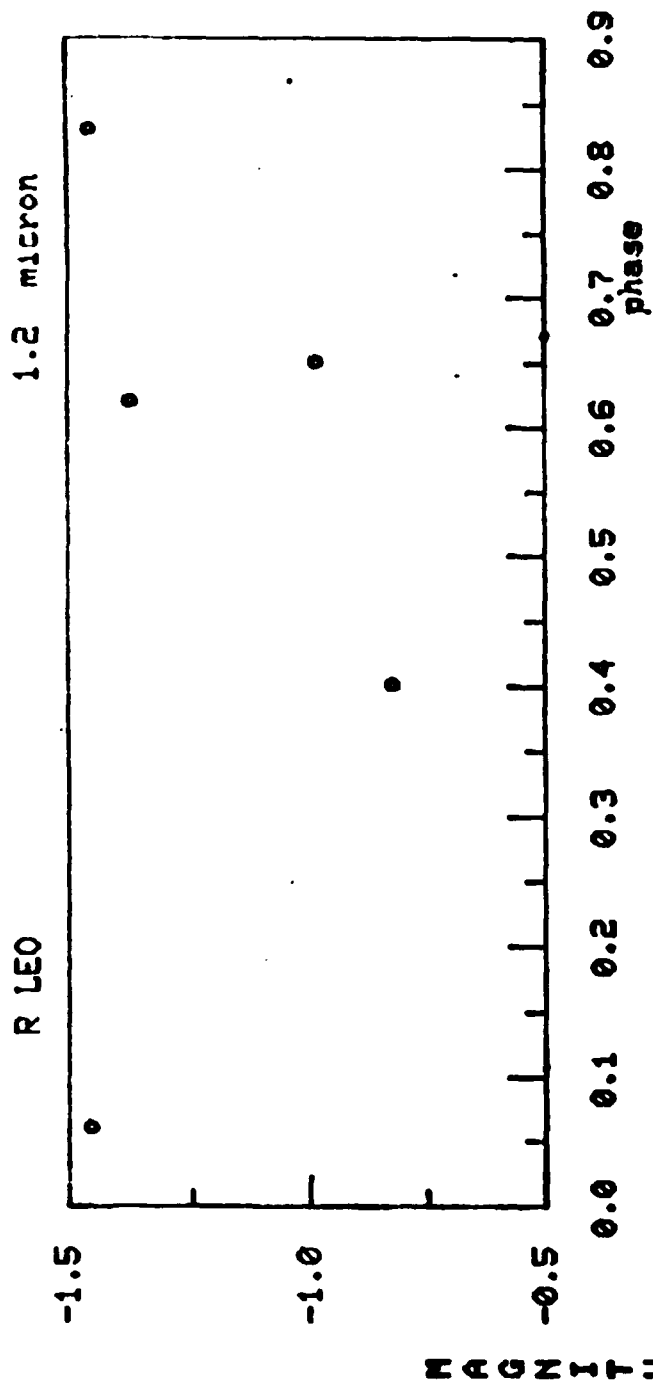


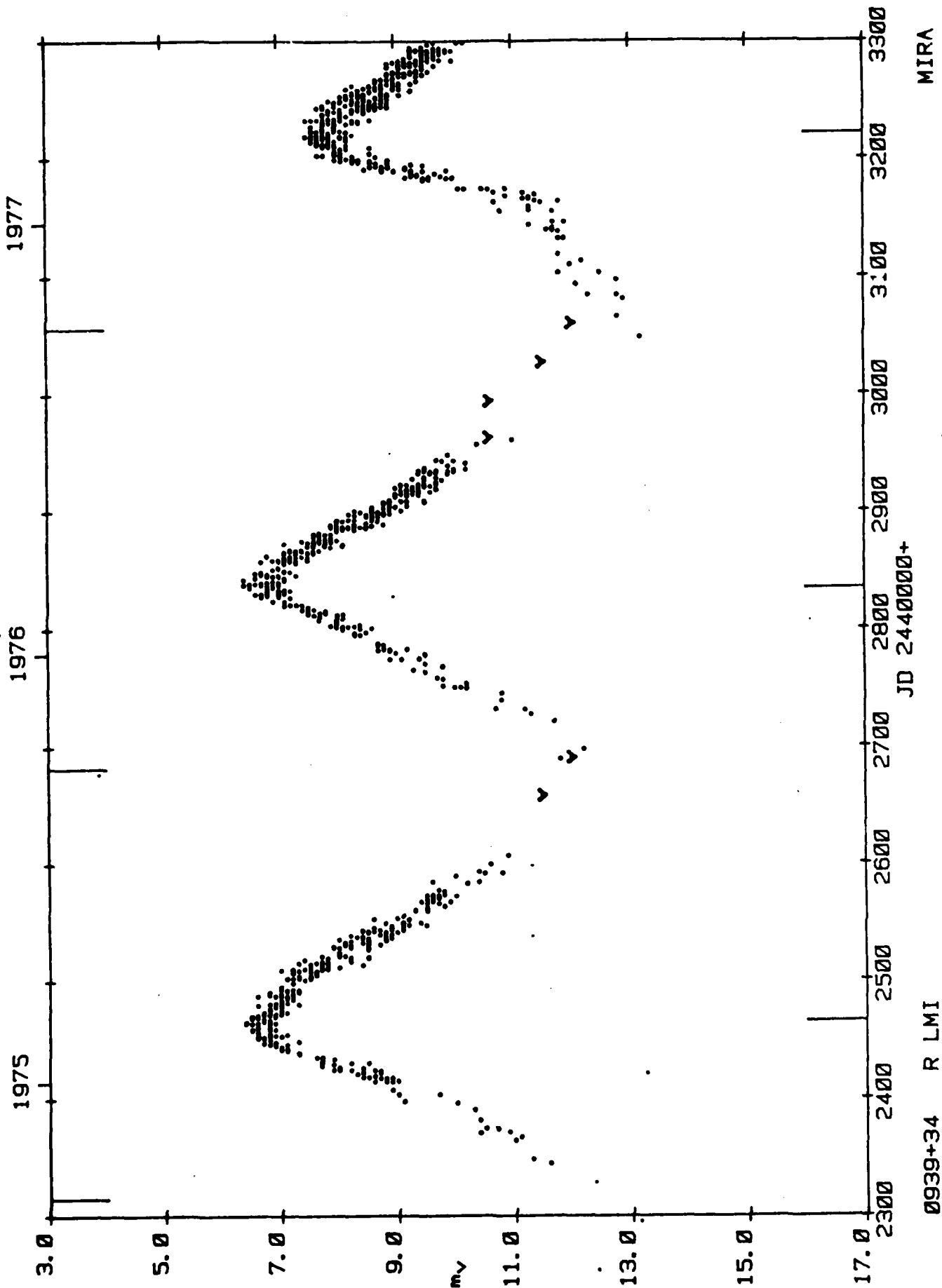




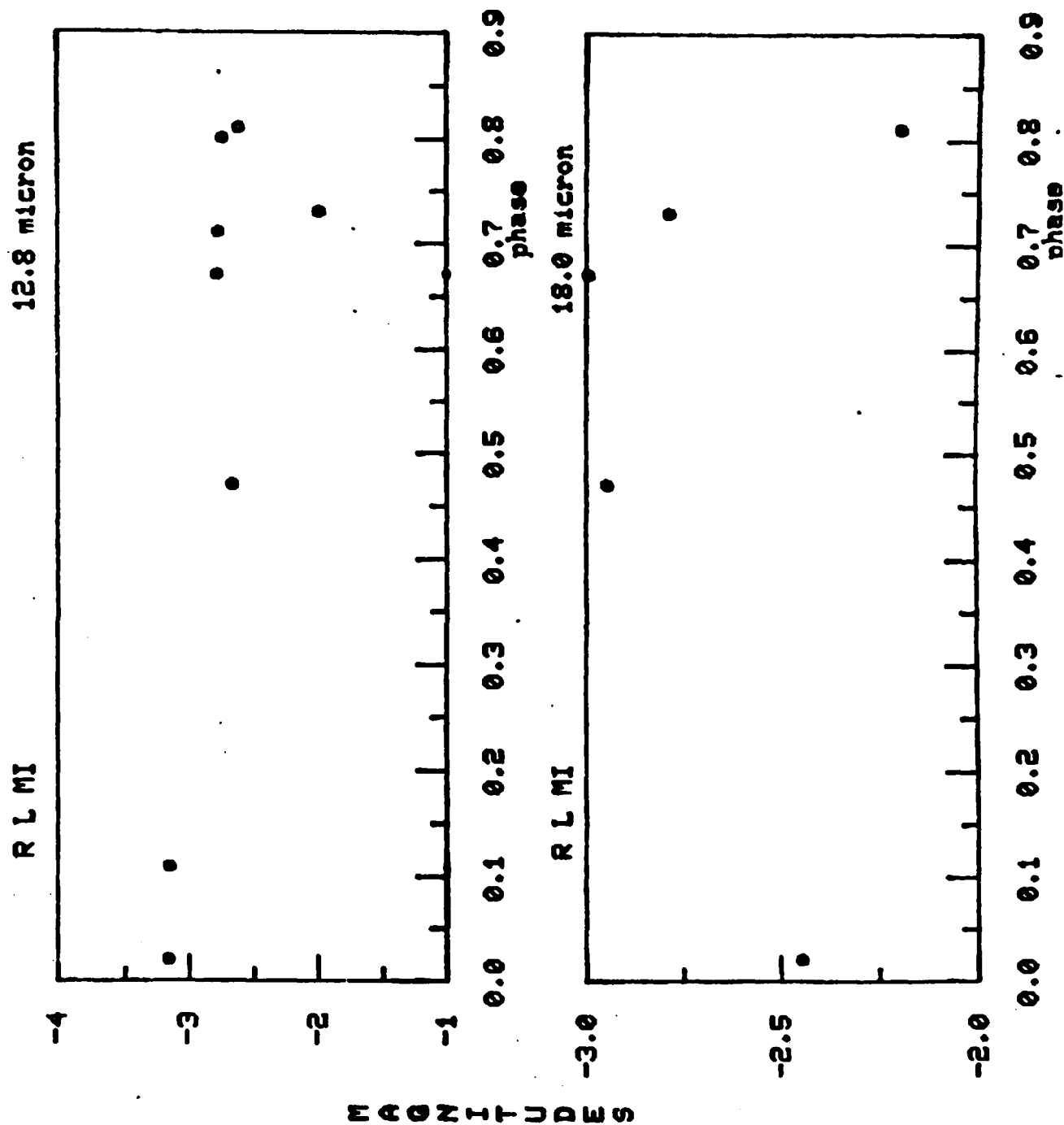


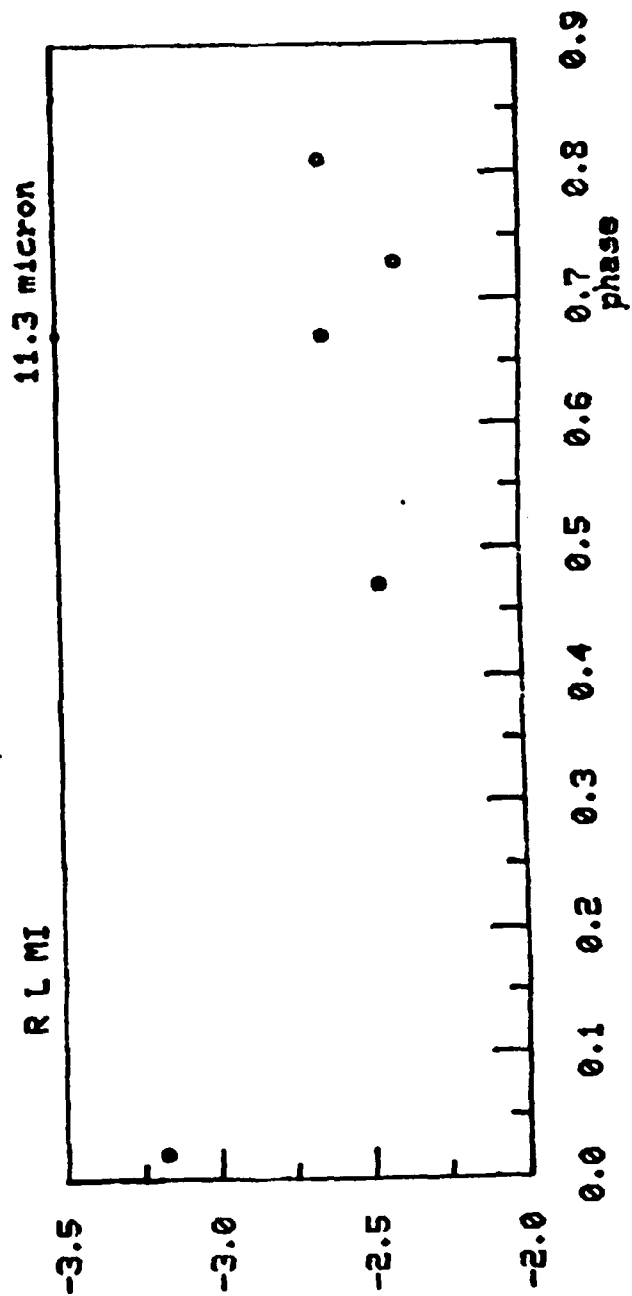
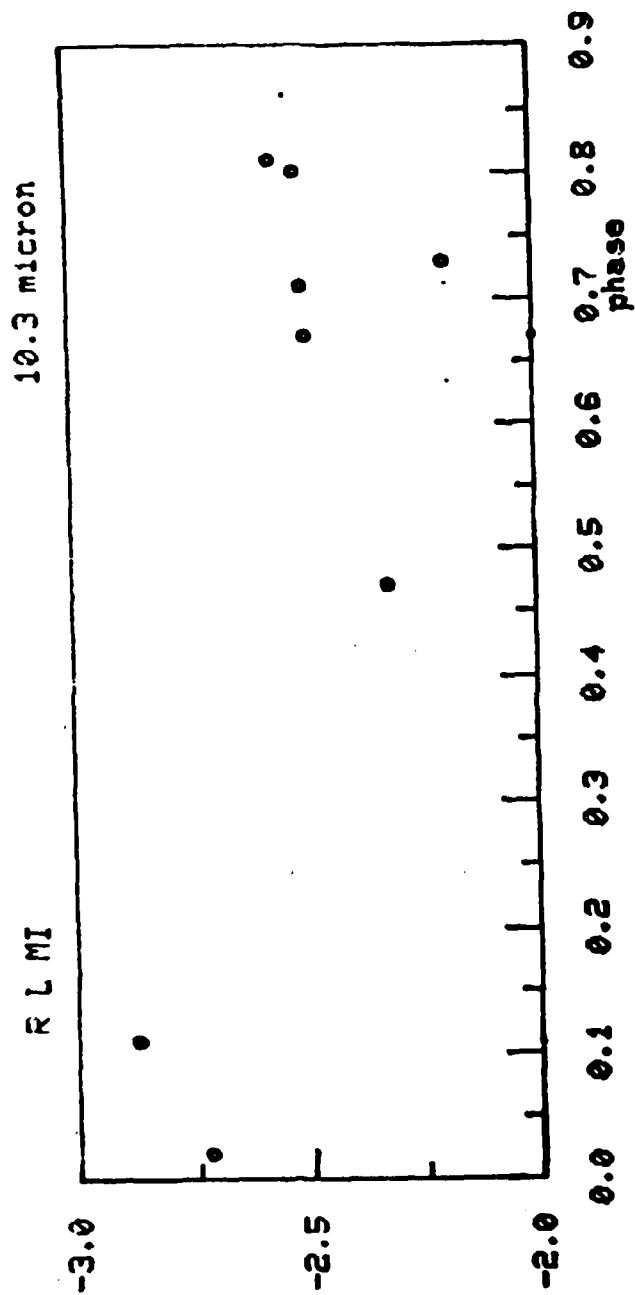




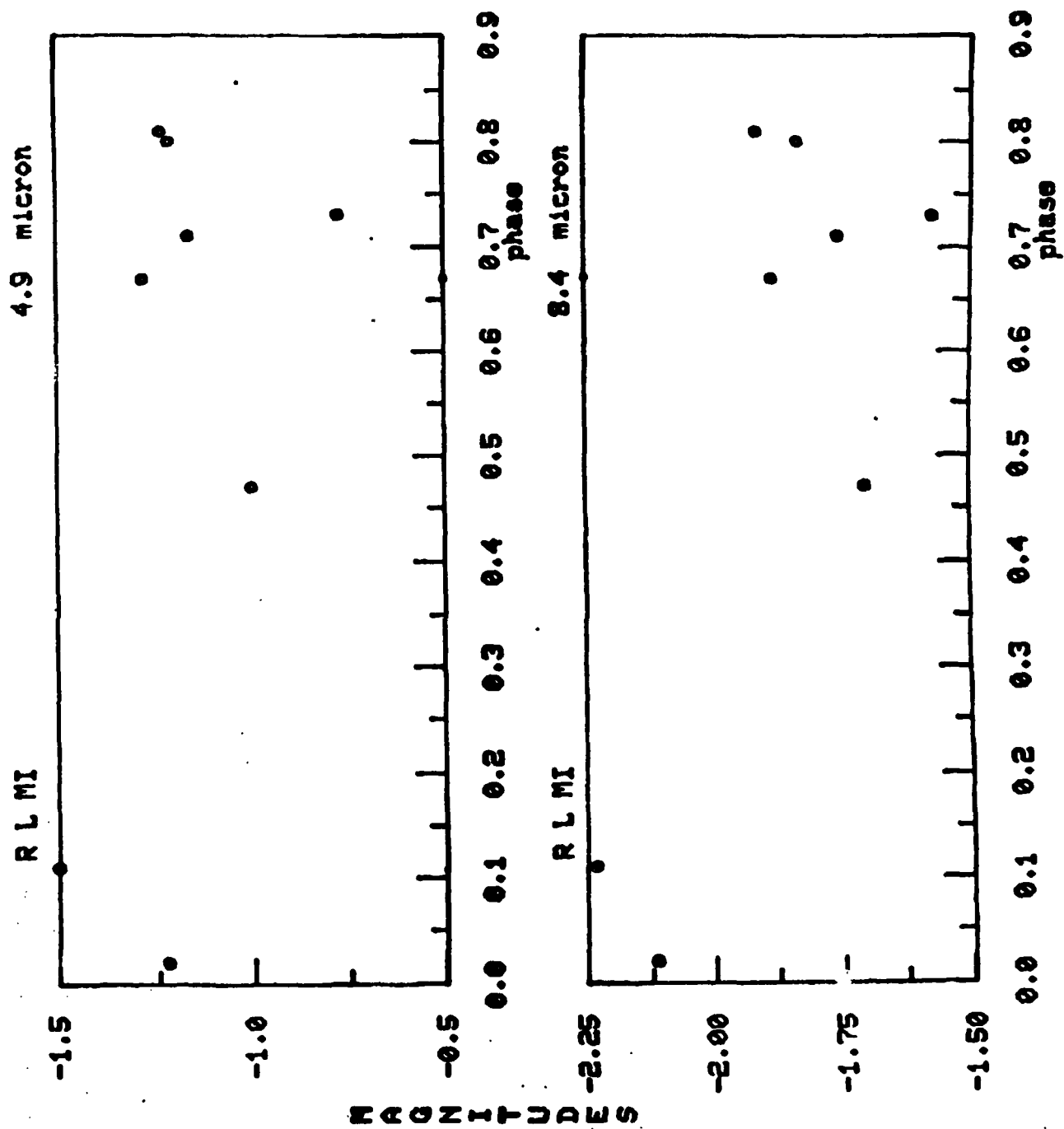


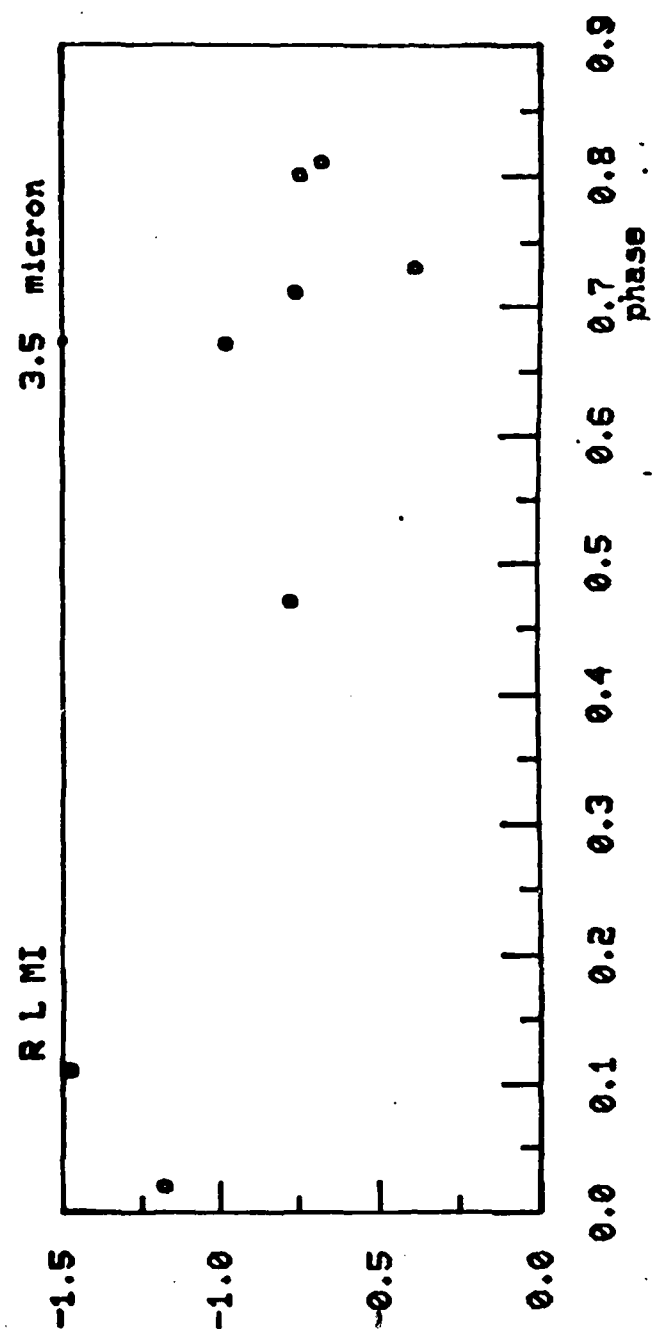
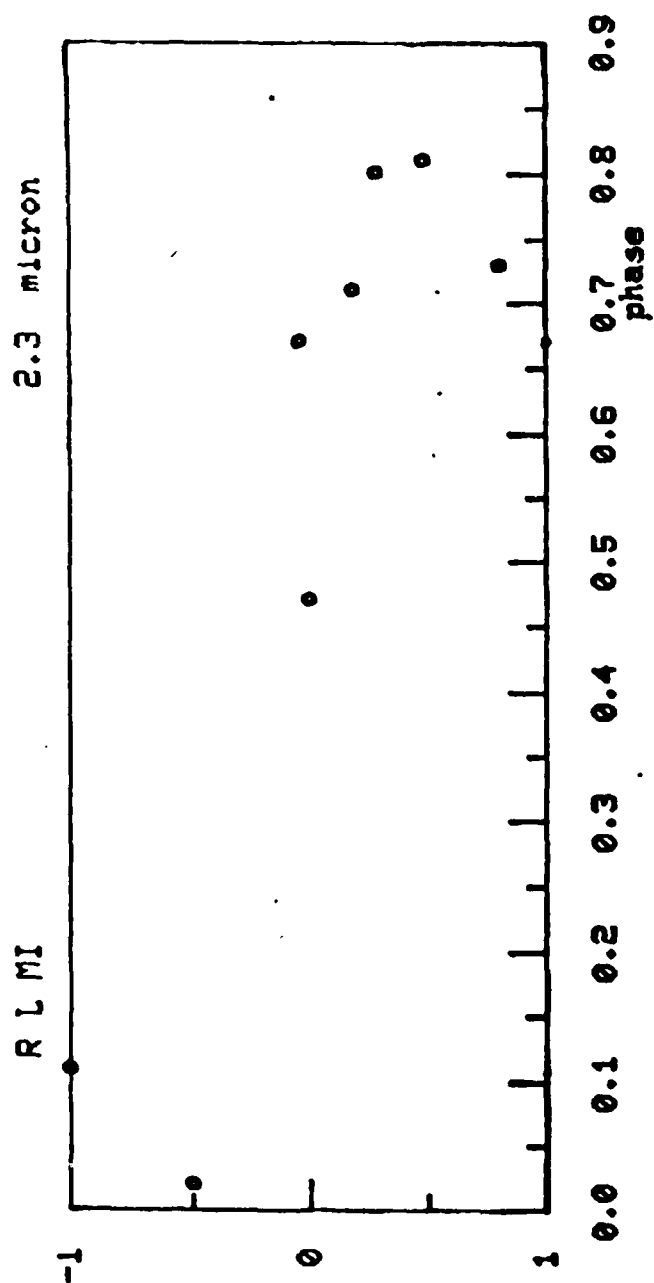




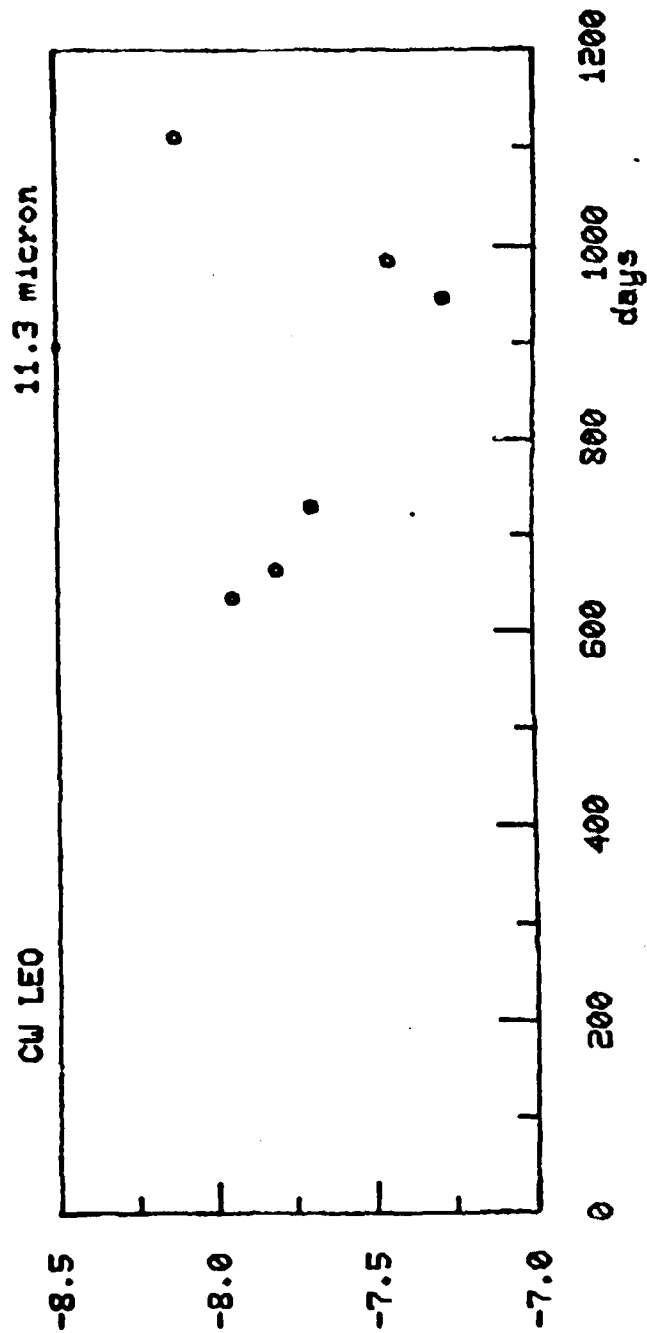
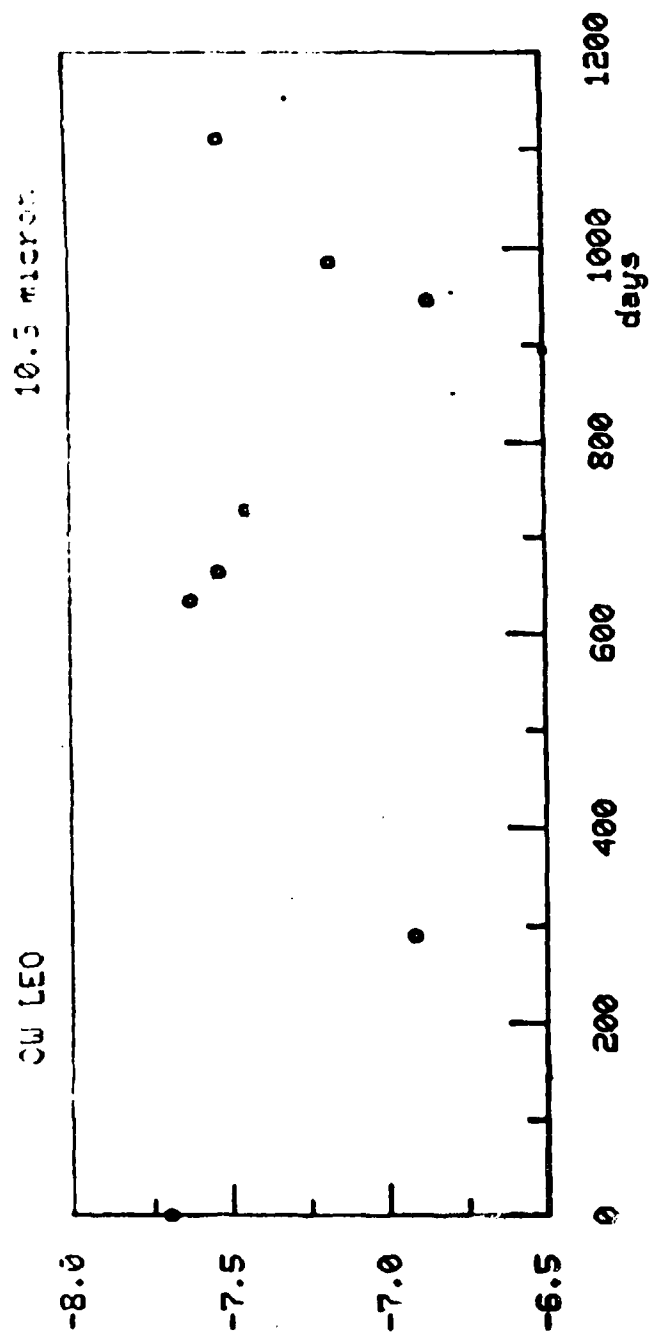


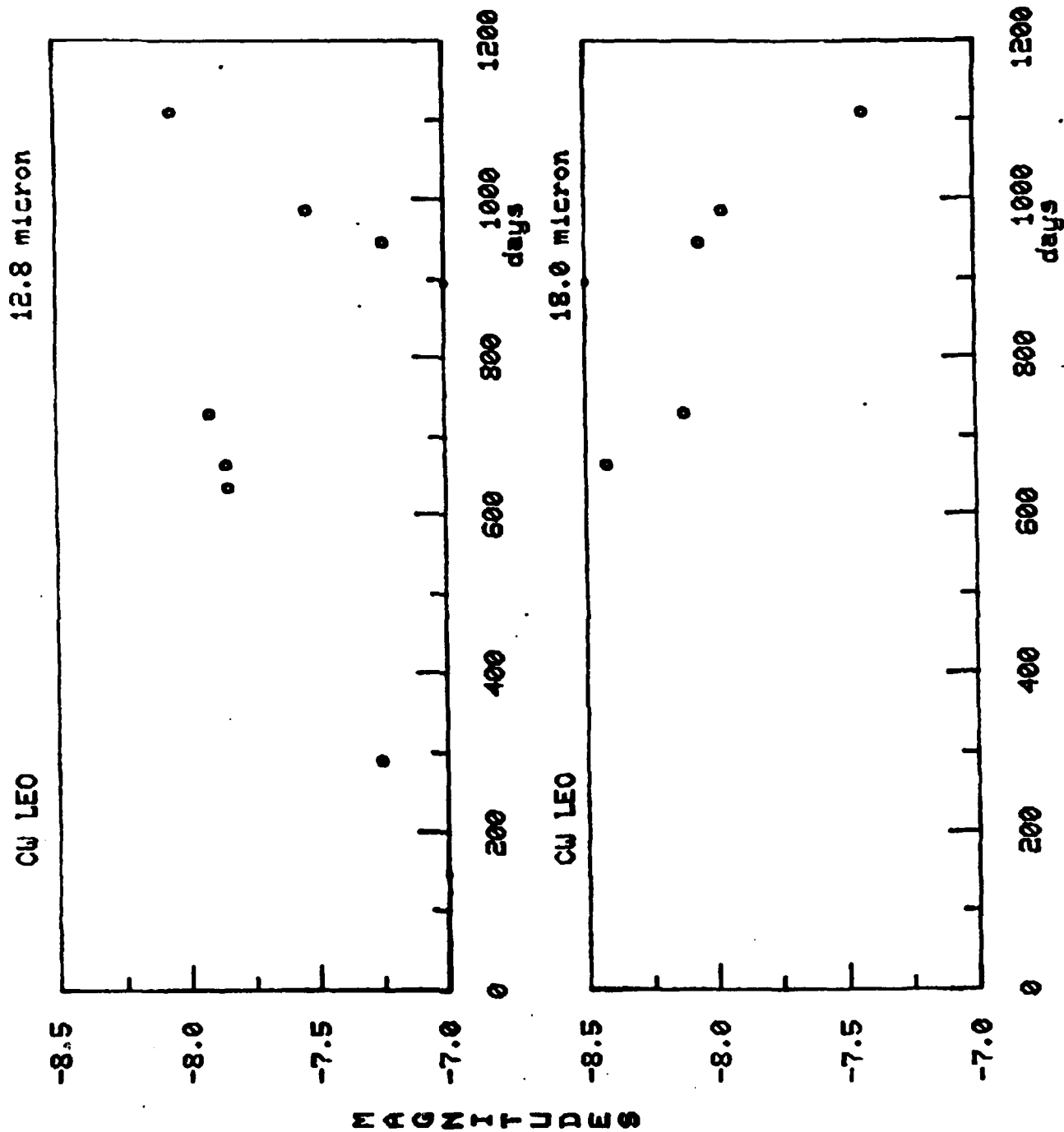
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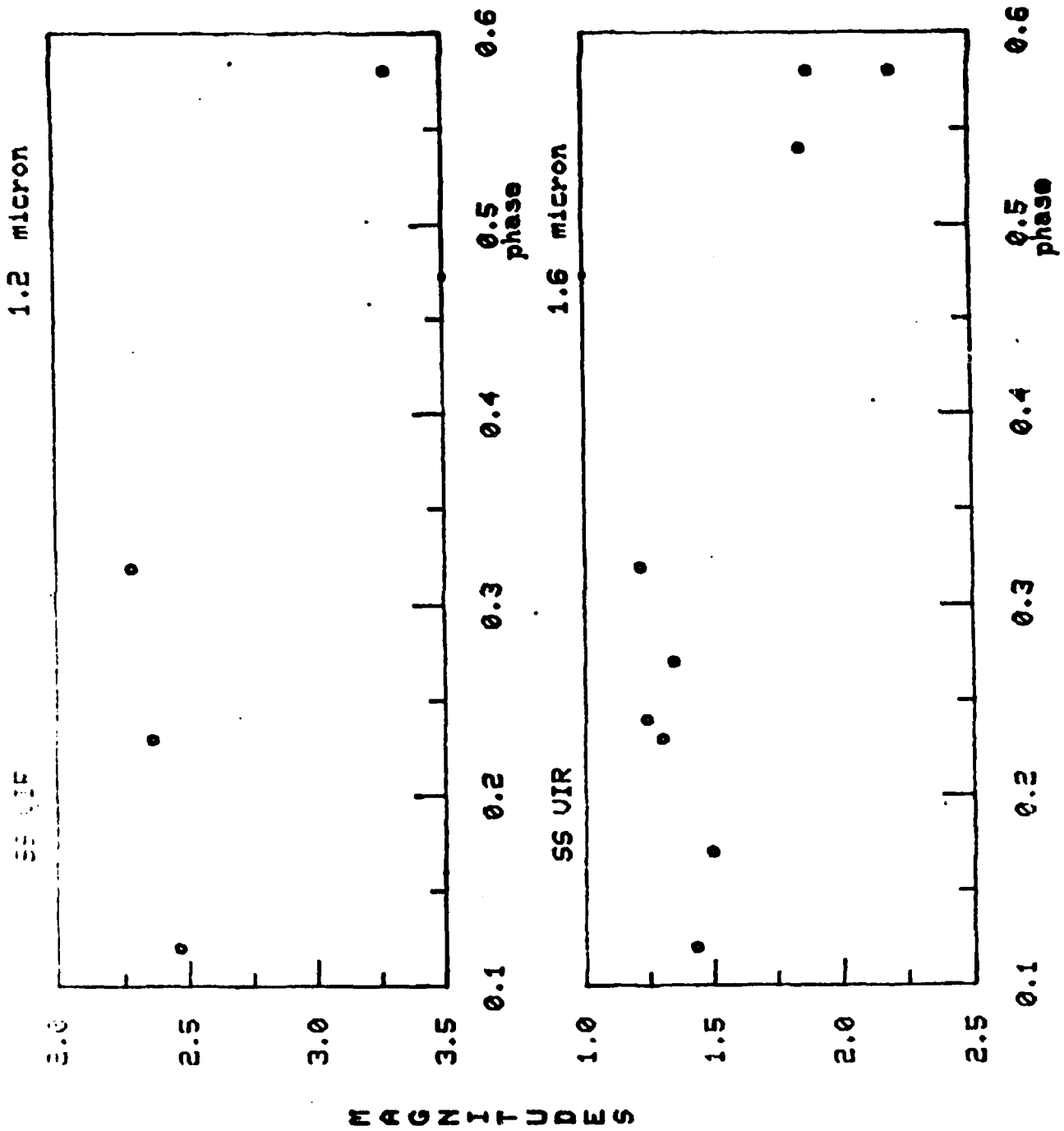


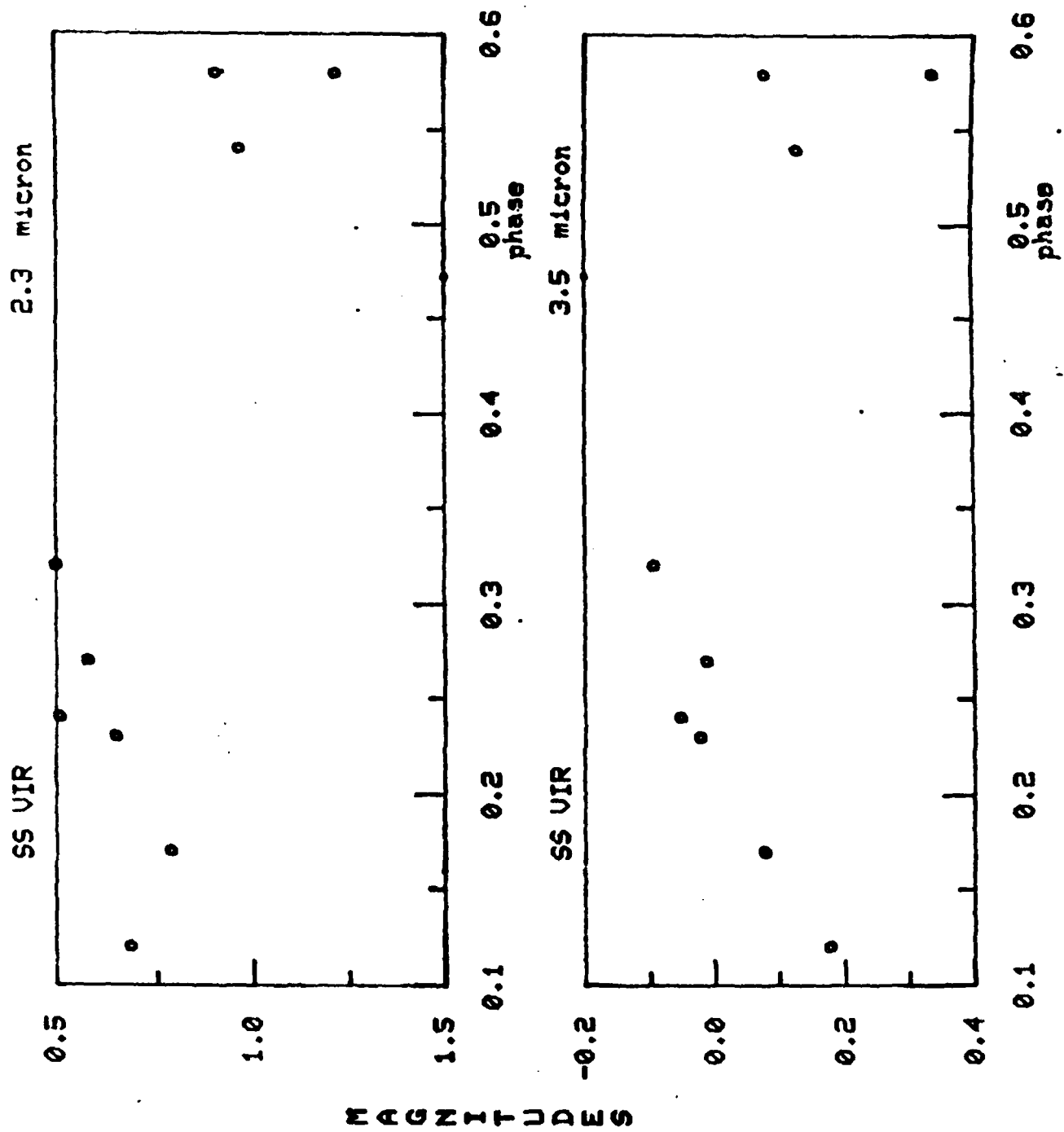


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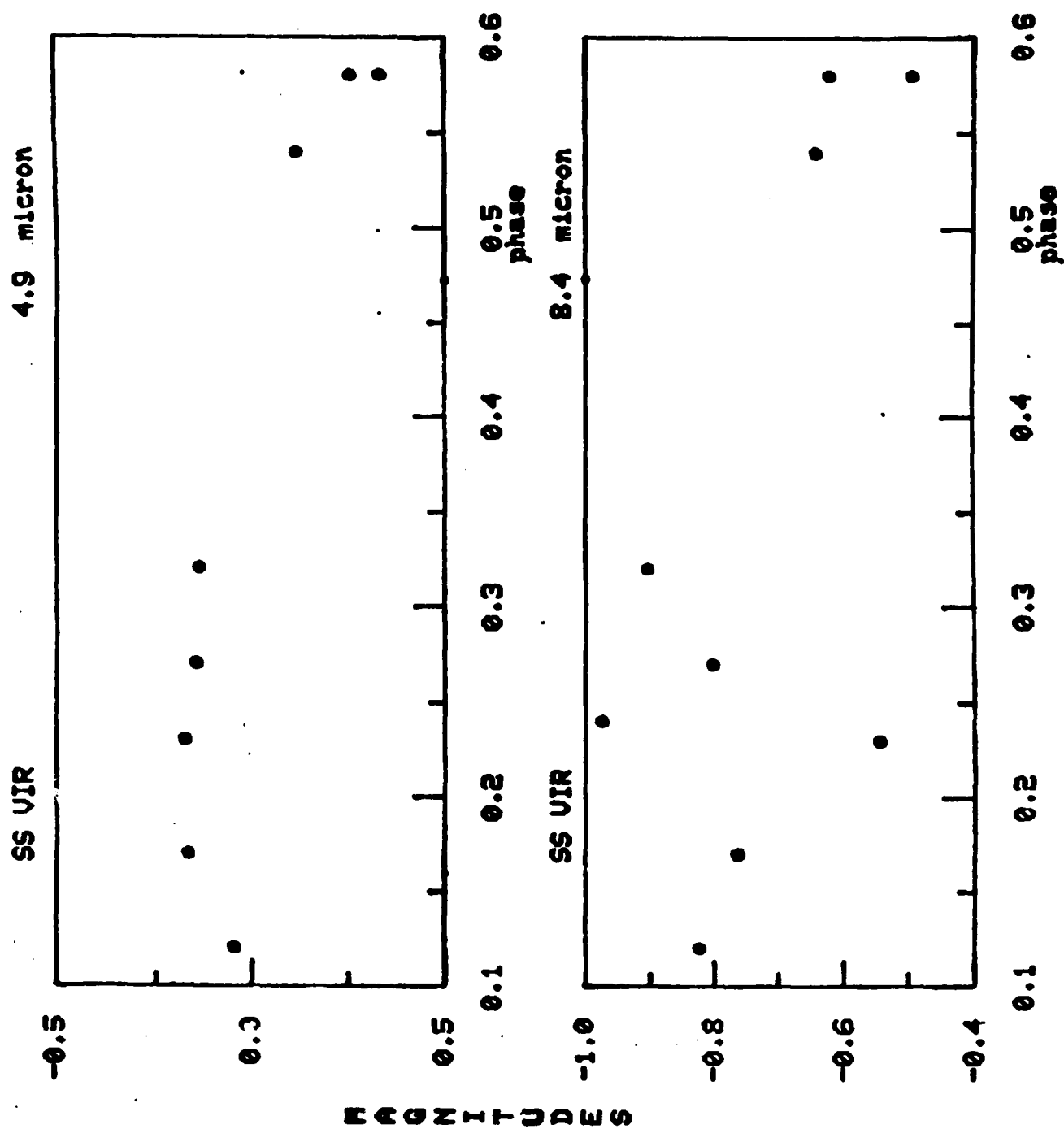


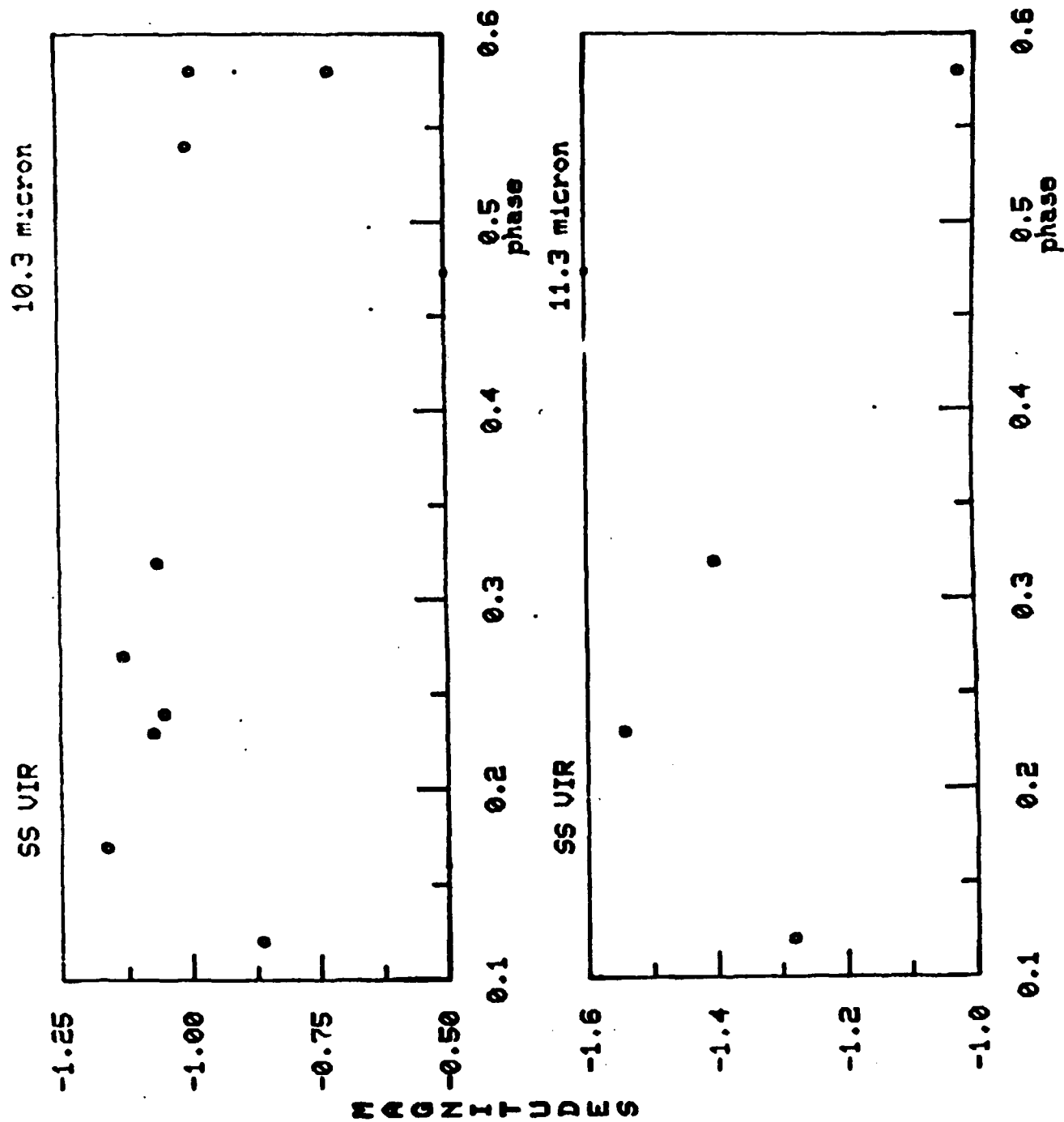


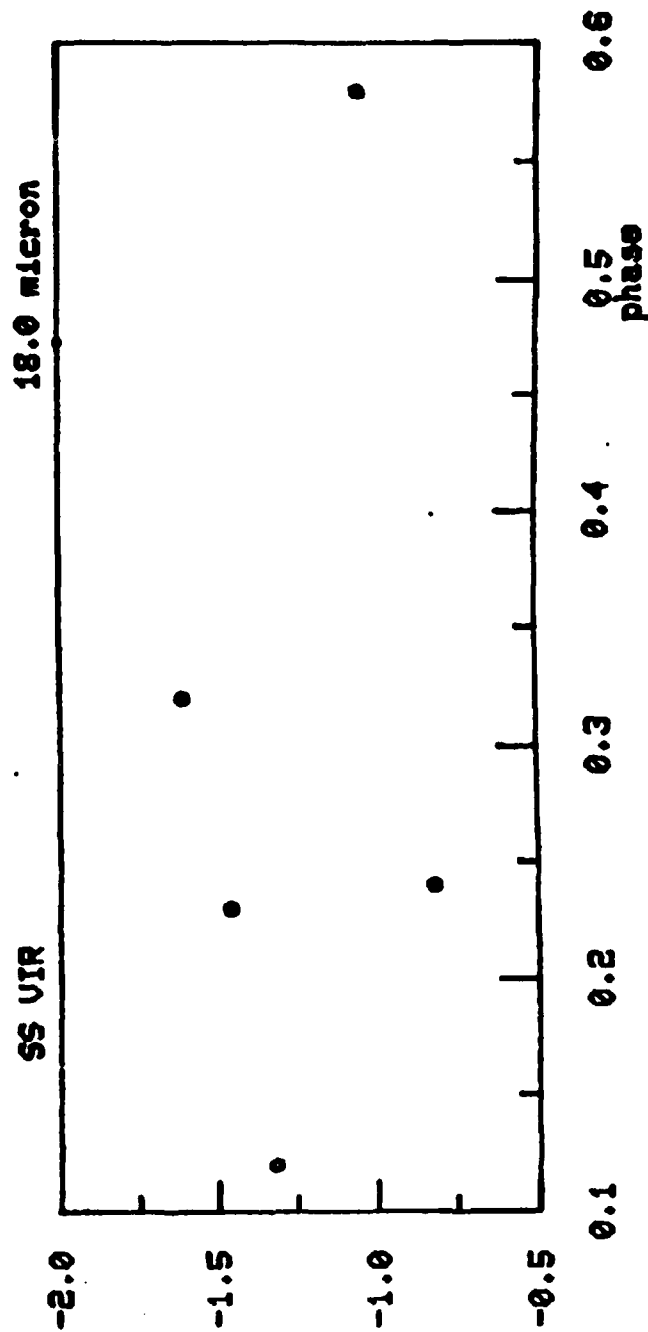
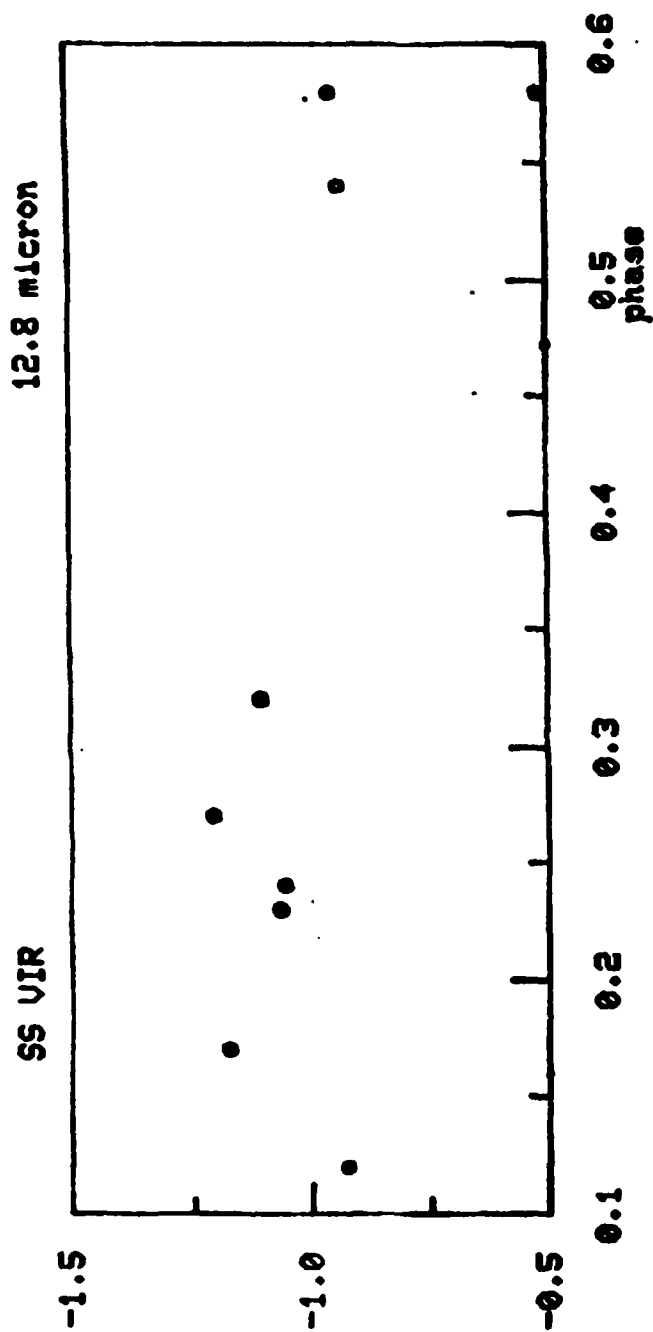


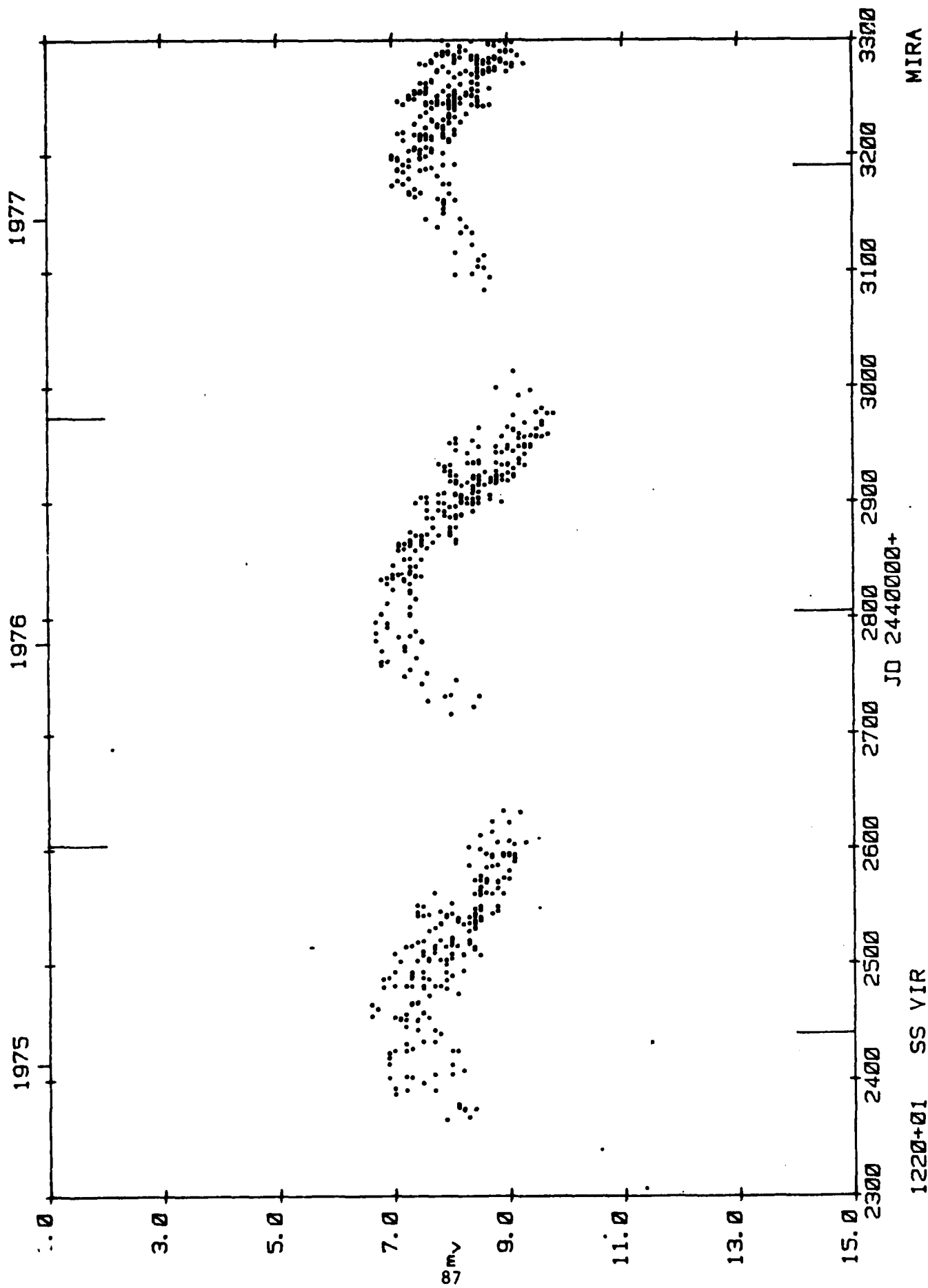


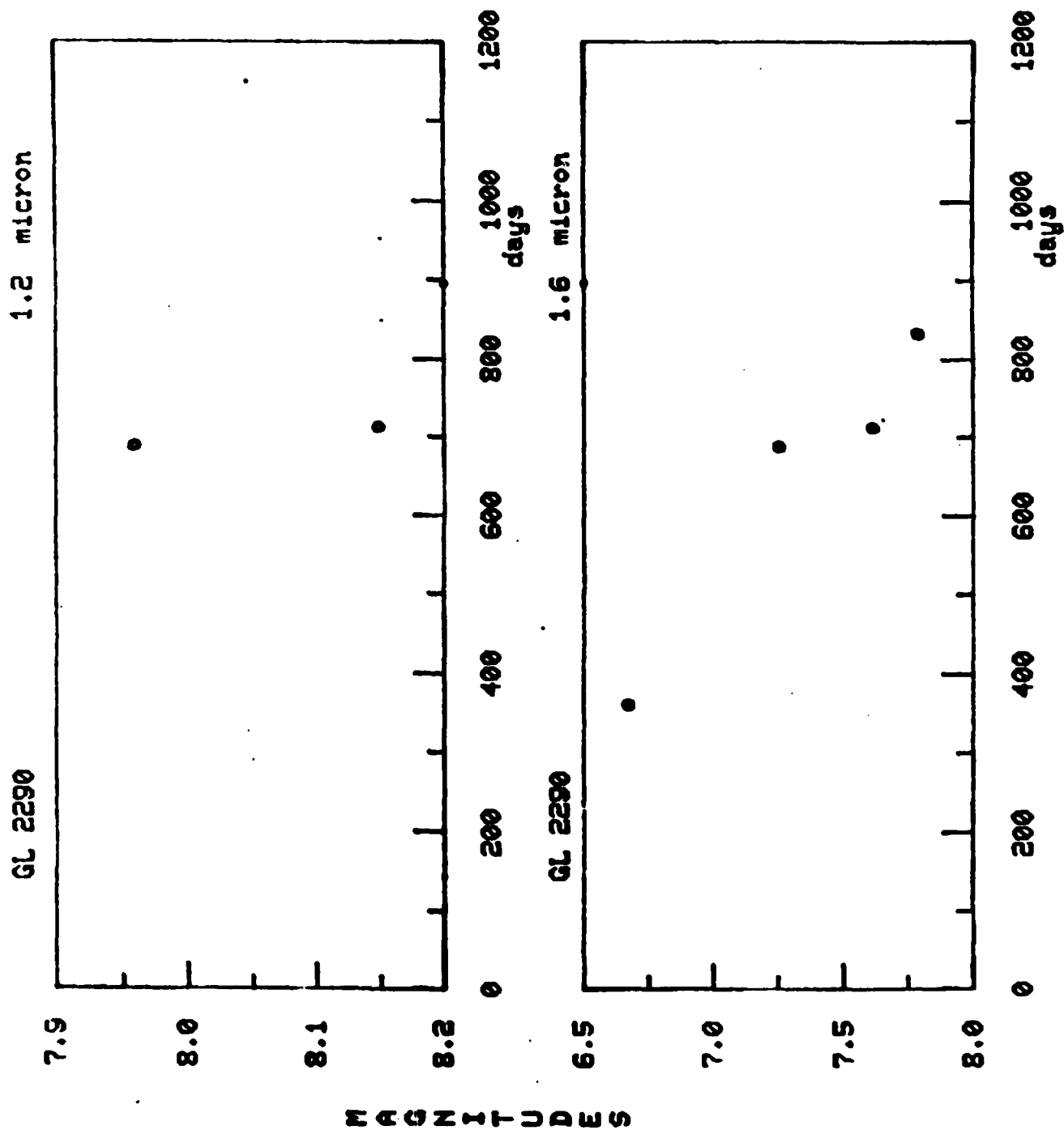


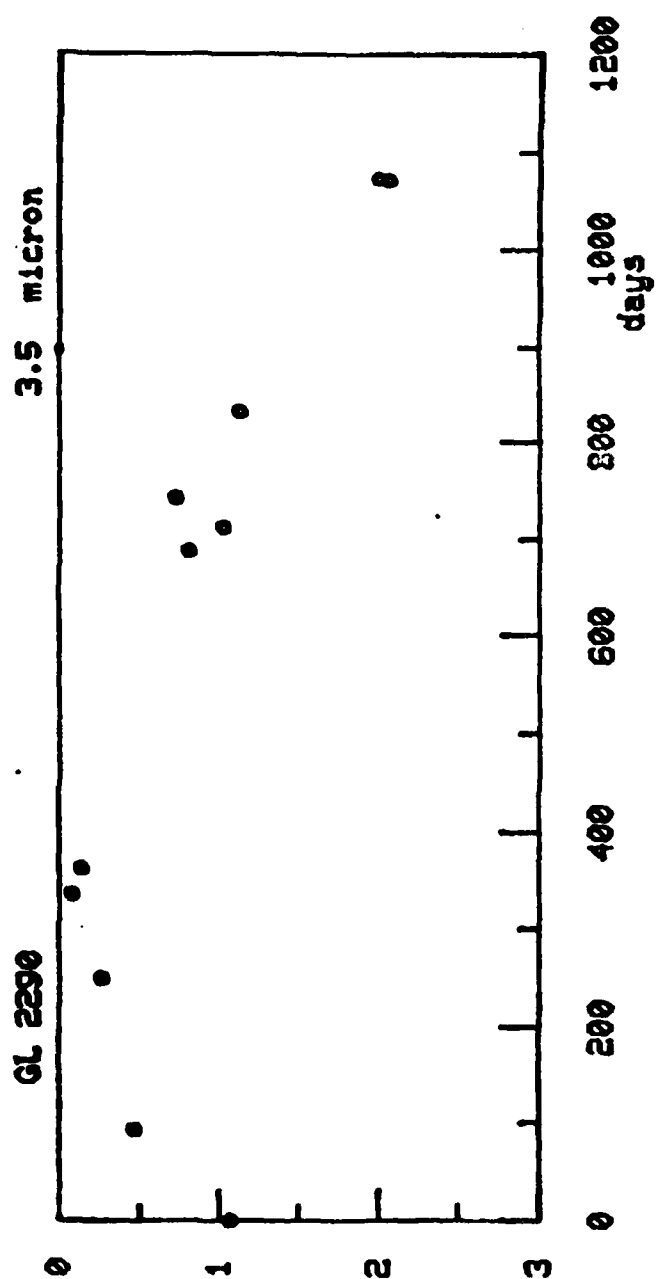
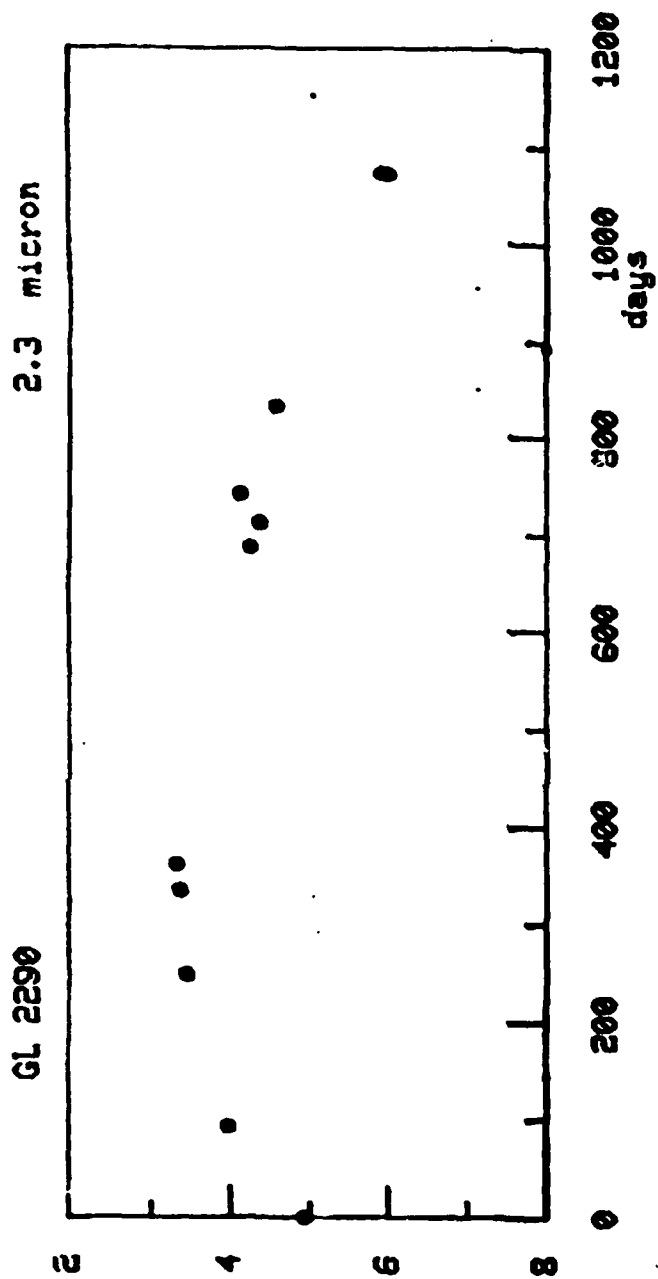




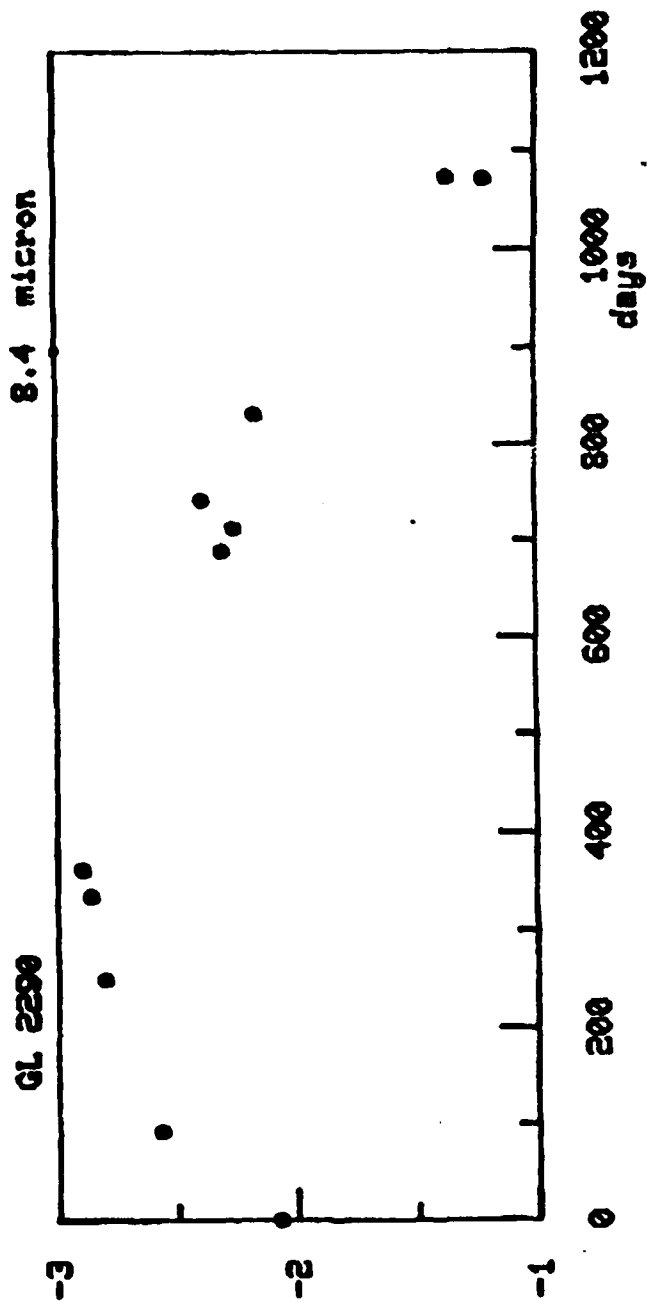
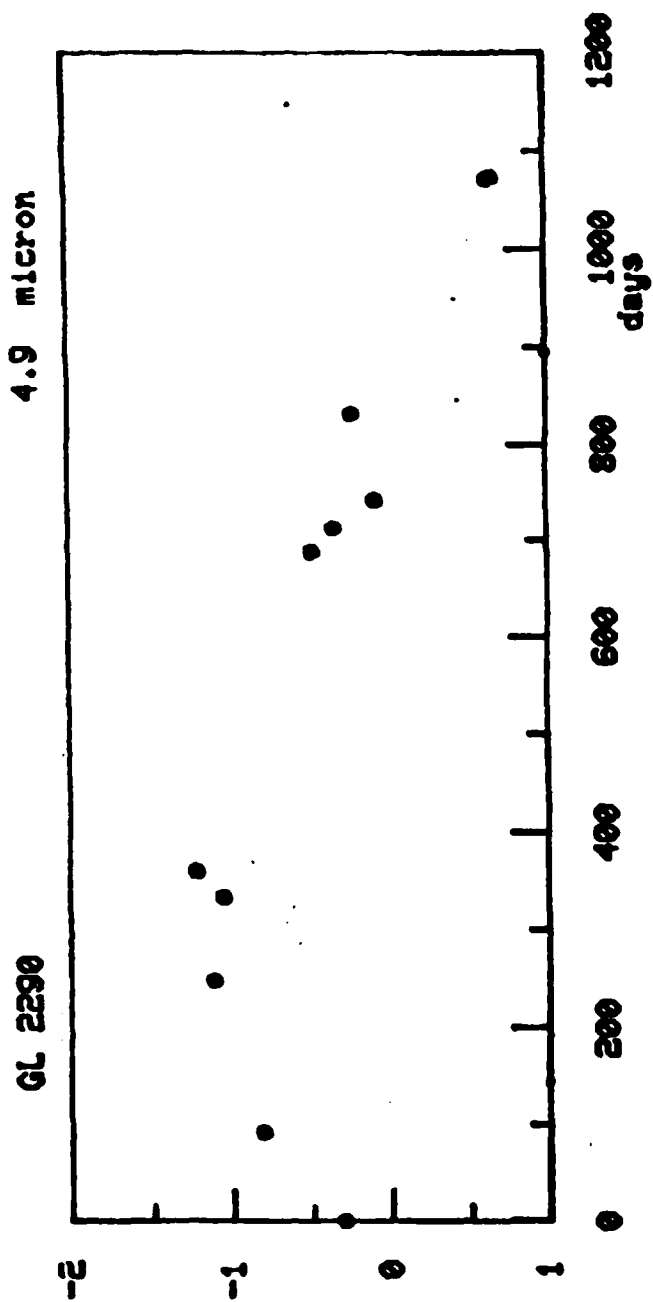




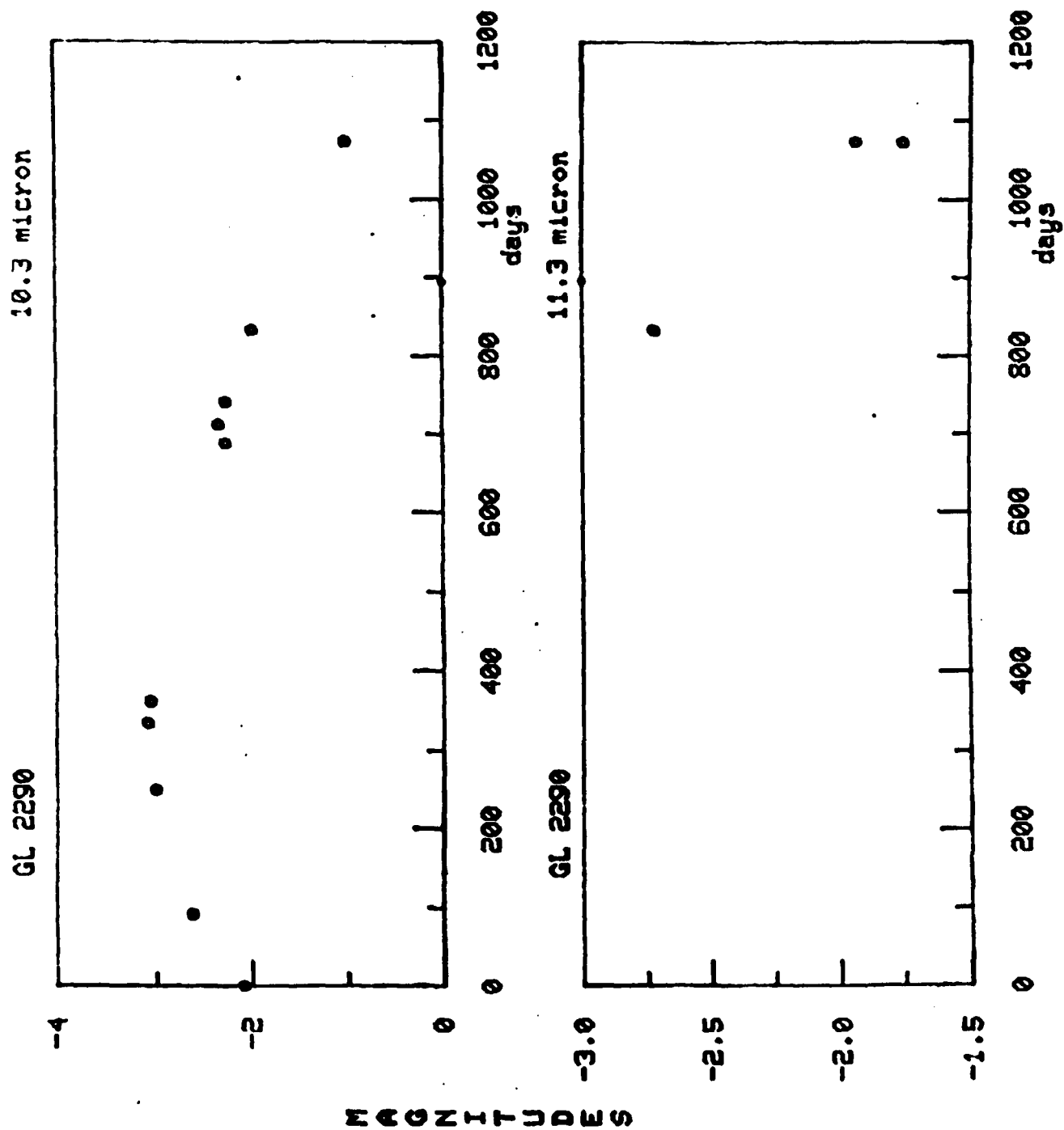




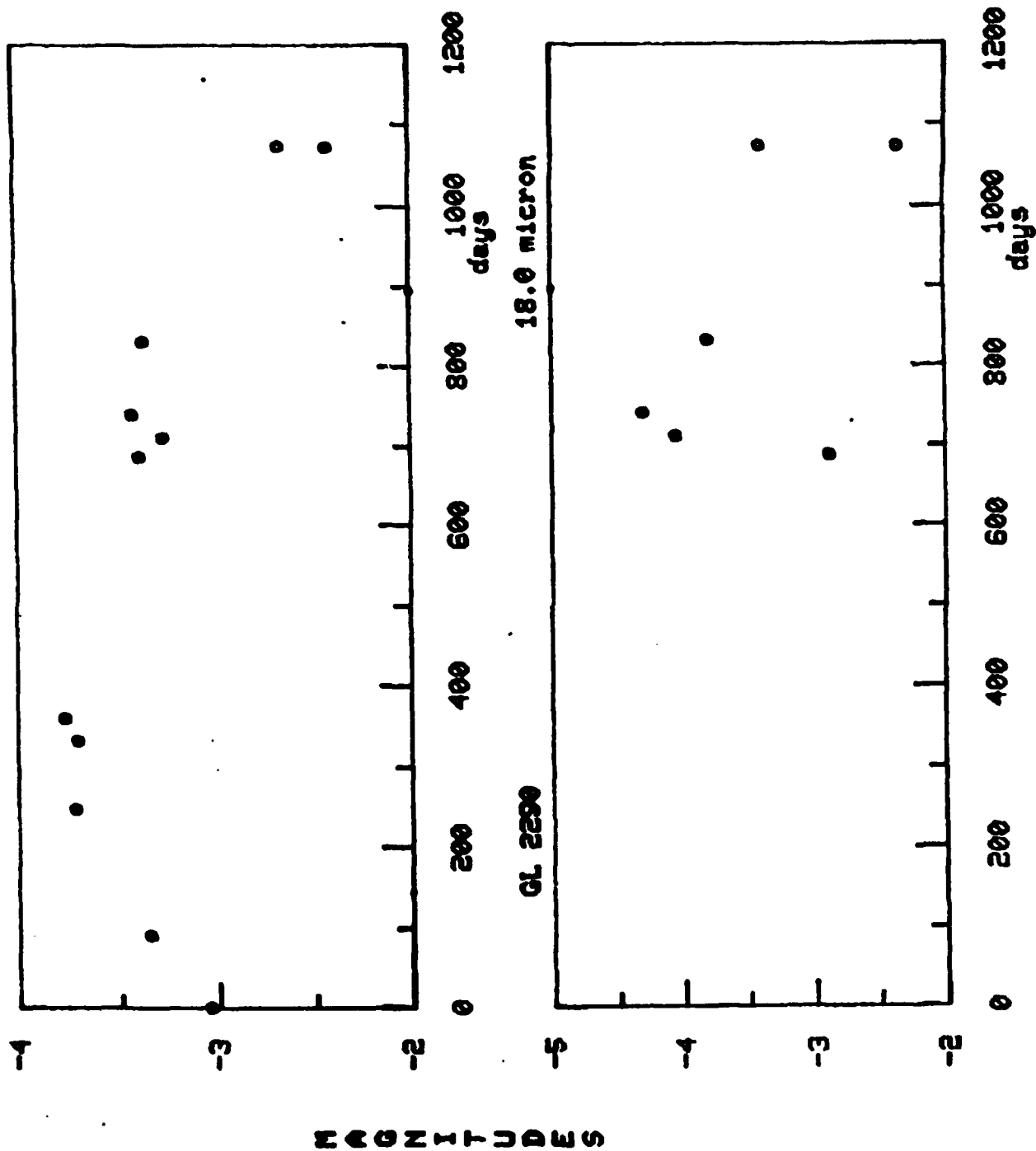
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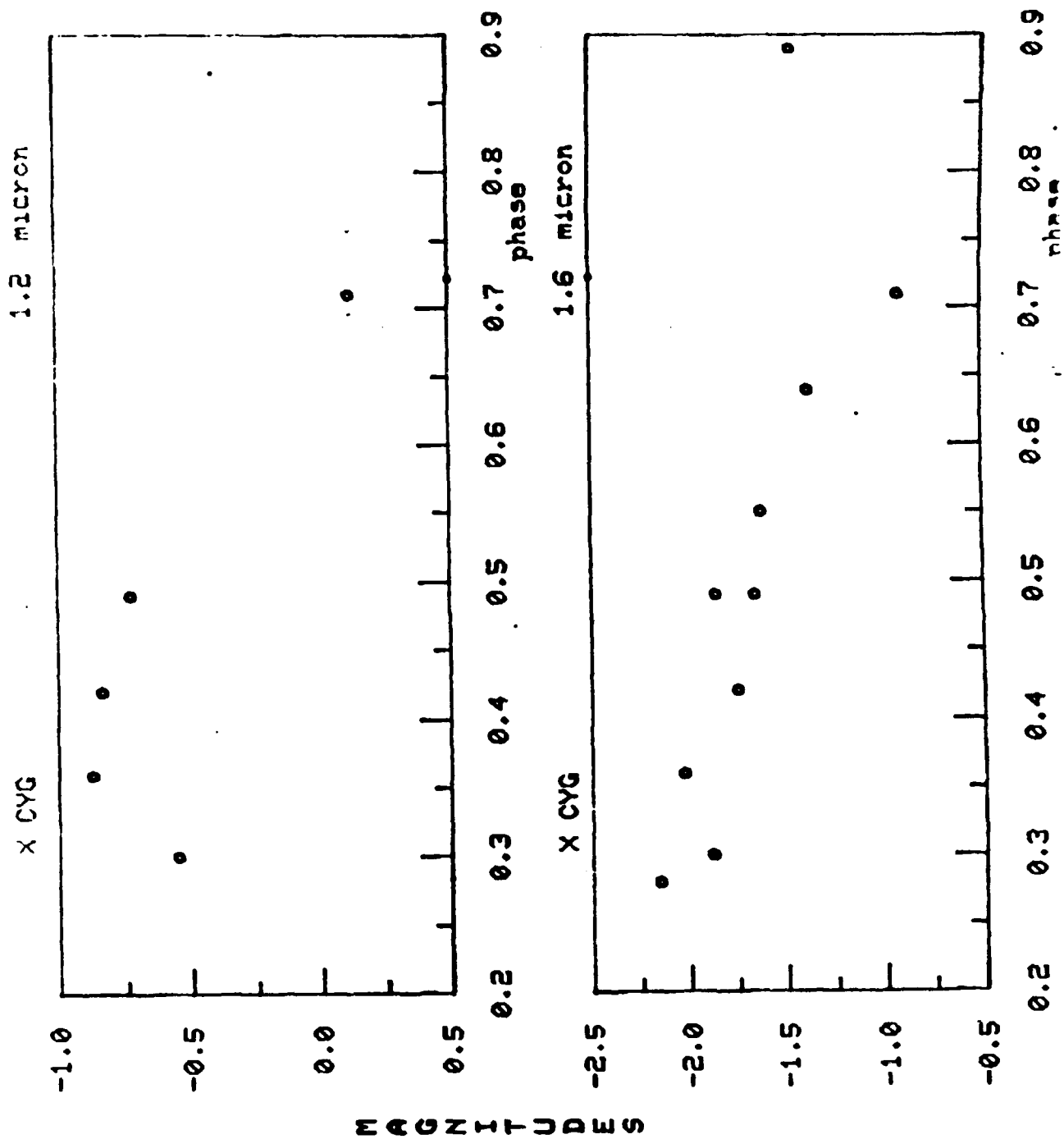


MAGNITUDES









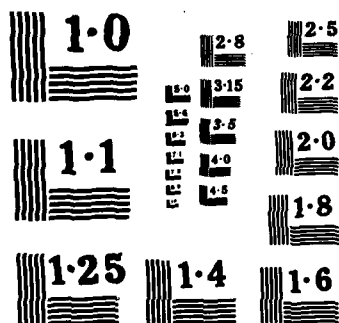
FURTHER GROUND-BASED STUDIES OF SOURCES FROM THE AFGL  
(AIR FORCE GEOPHYSI.. (U) CALIFORNIA UNIV SAN DIEGO LA  
JOLLA CENTER FOR ASTROPHYSICS AN.. B JONES ET AL.

NL

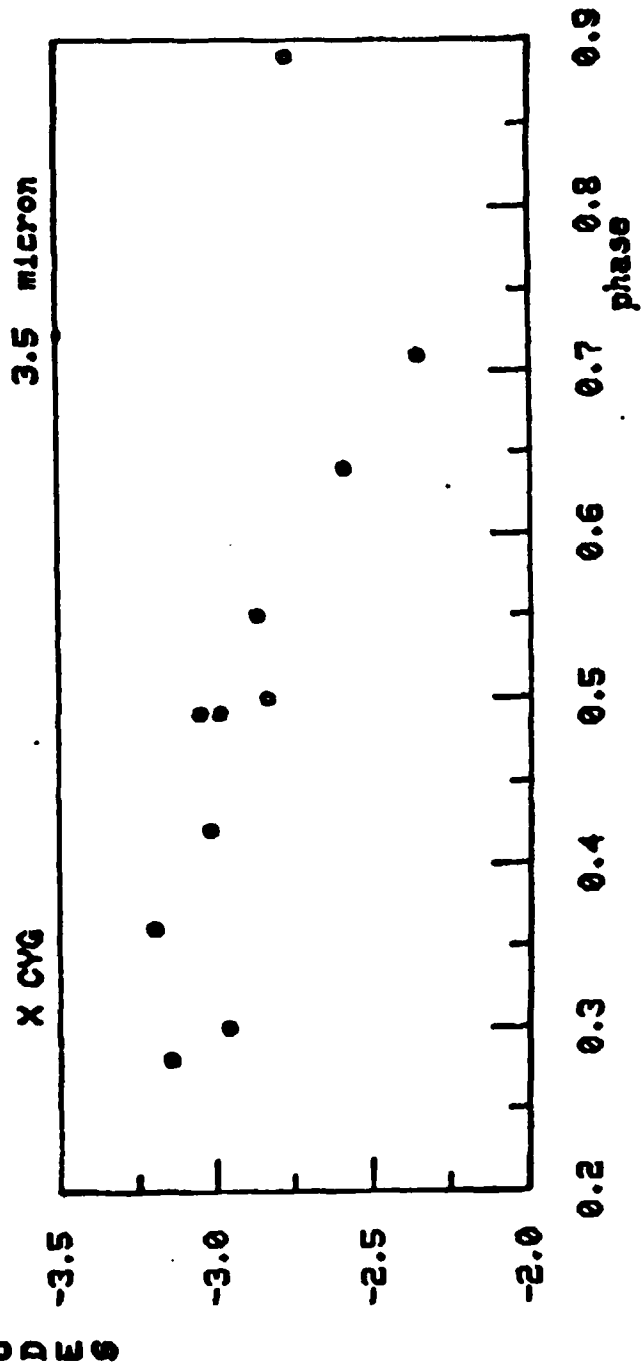
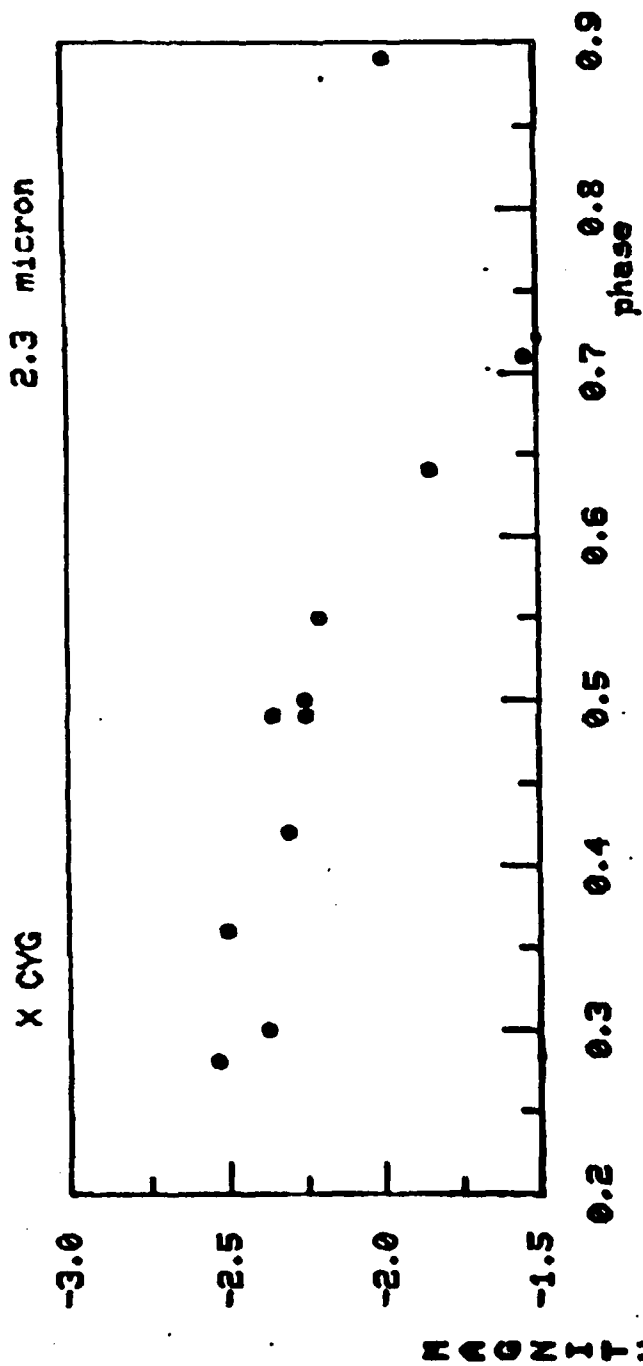
MAR 84 AFGL-TR-84-0114 F19628-80-C-0063 F/G 3/1

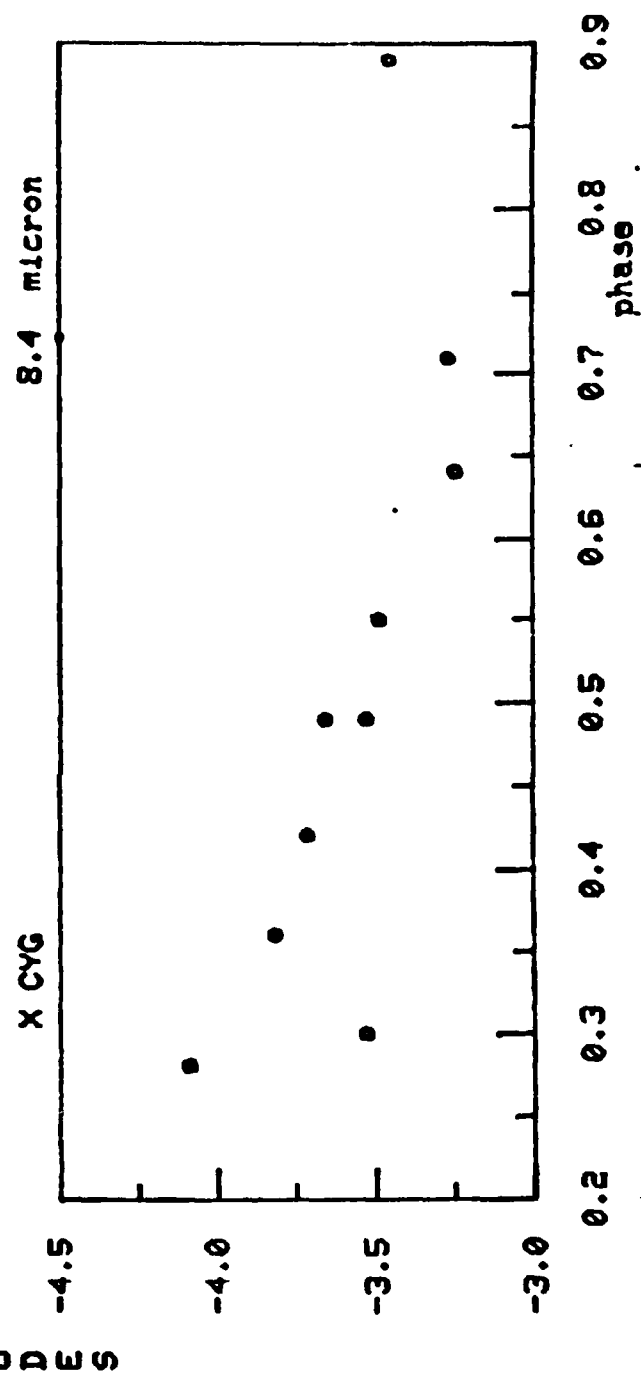
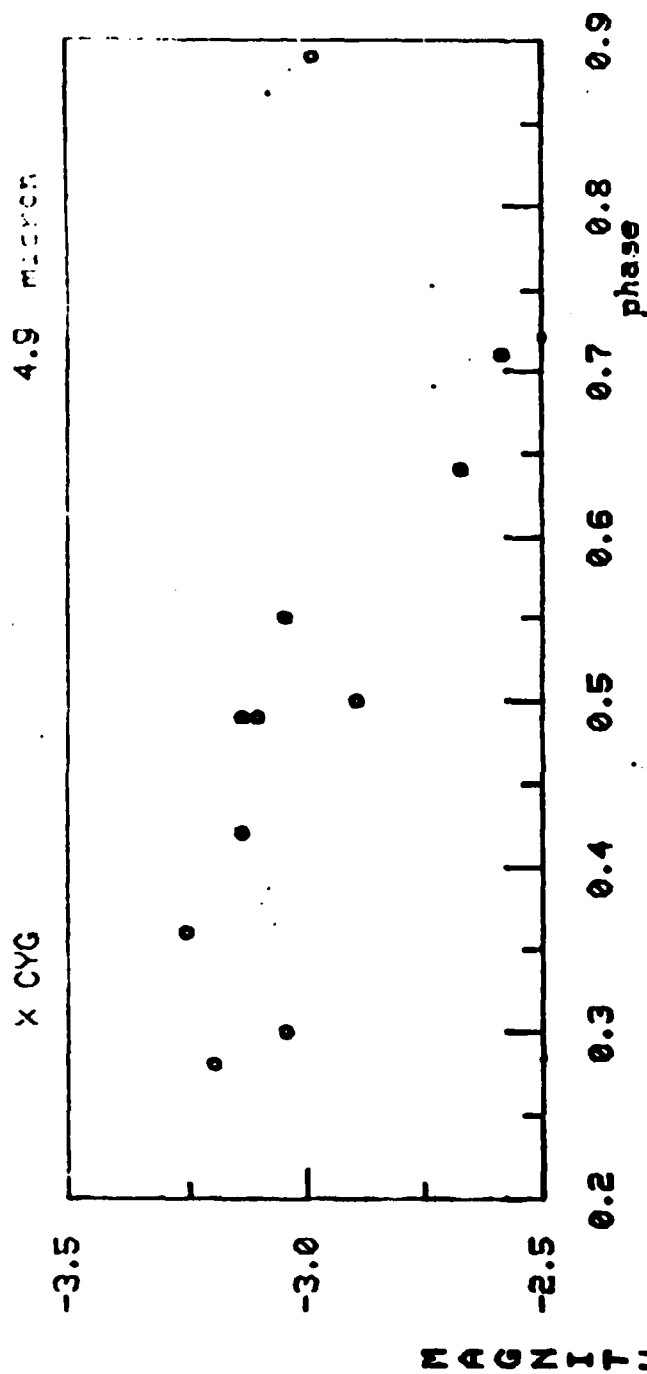
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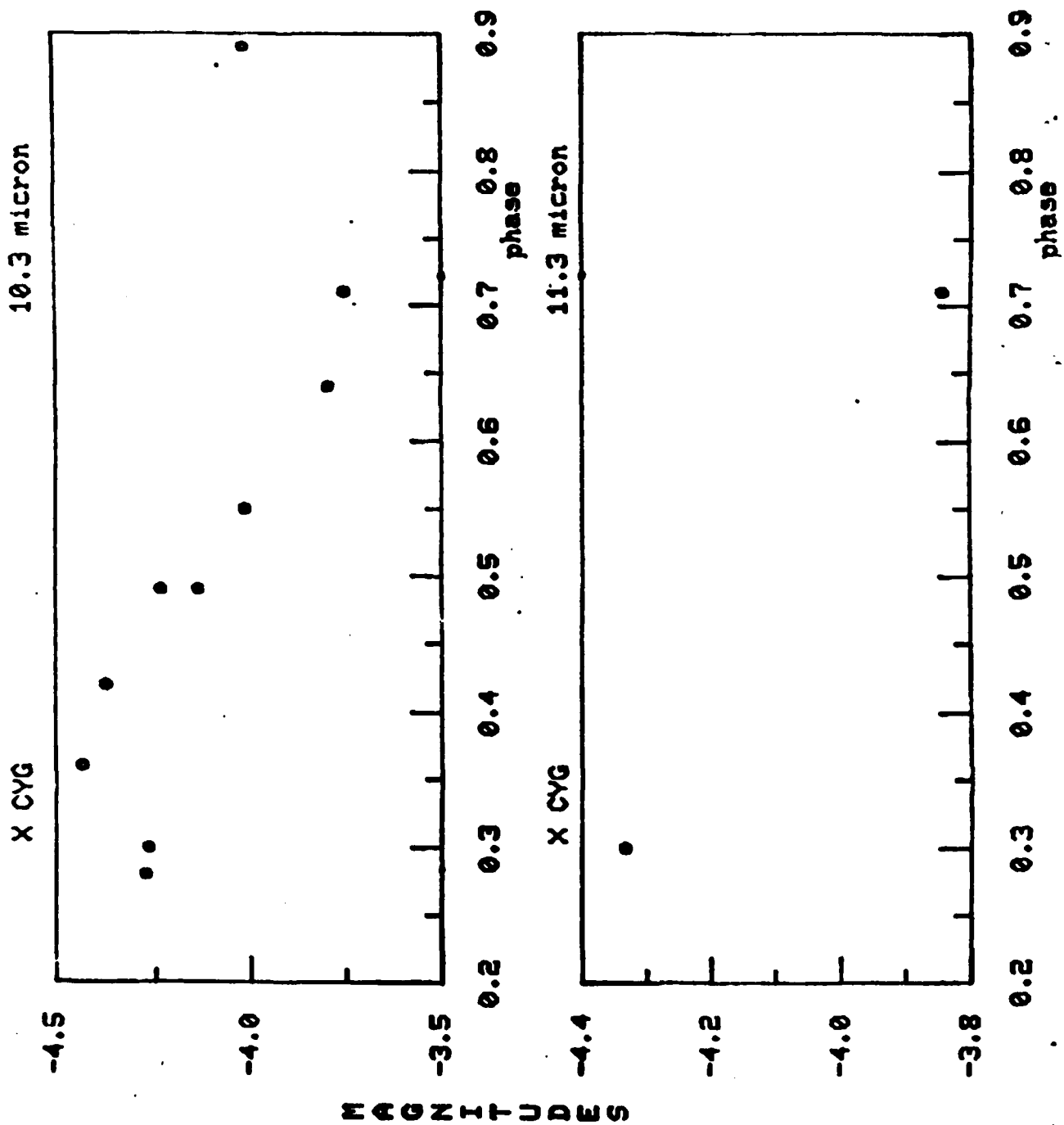
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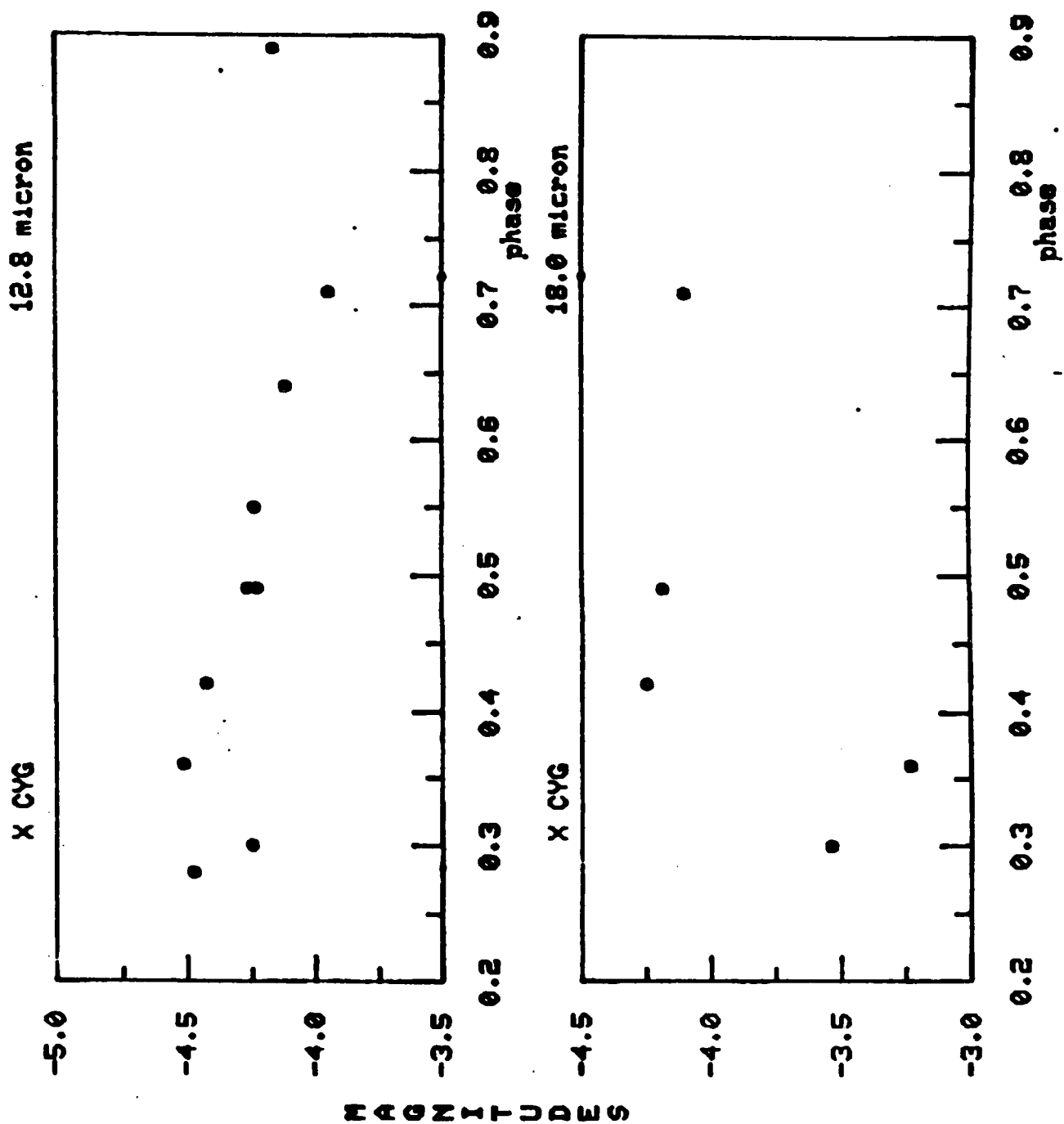


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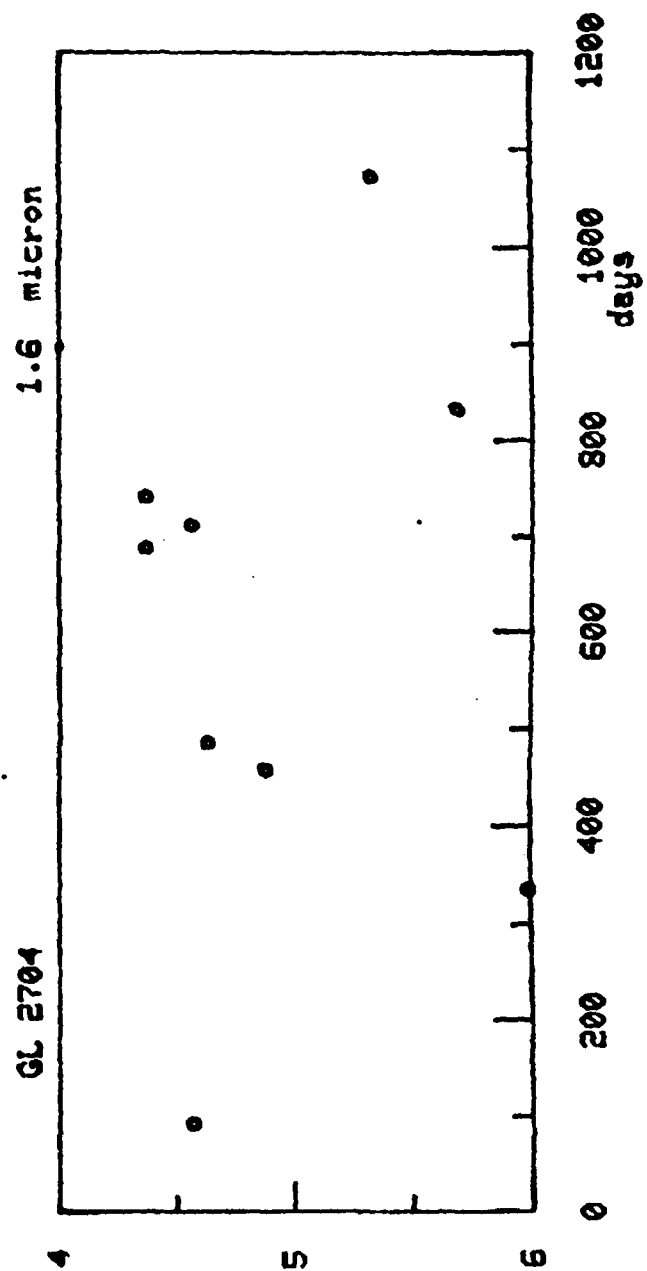
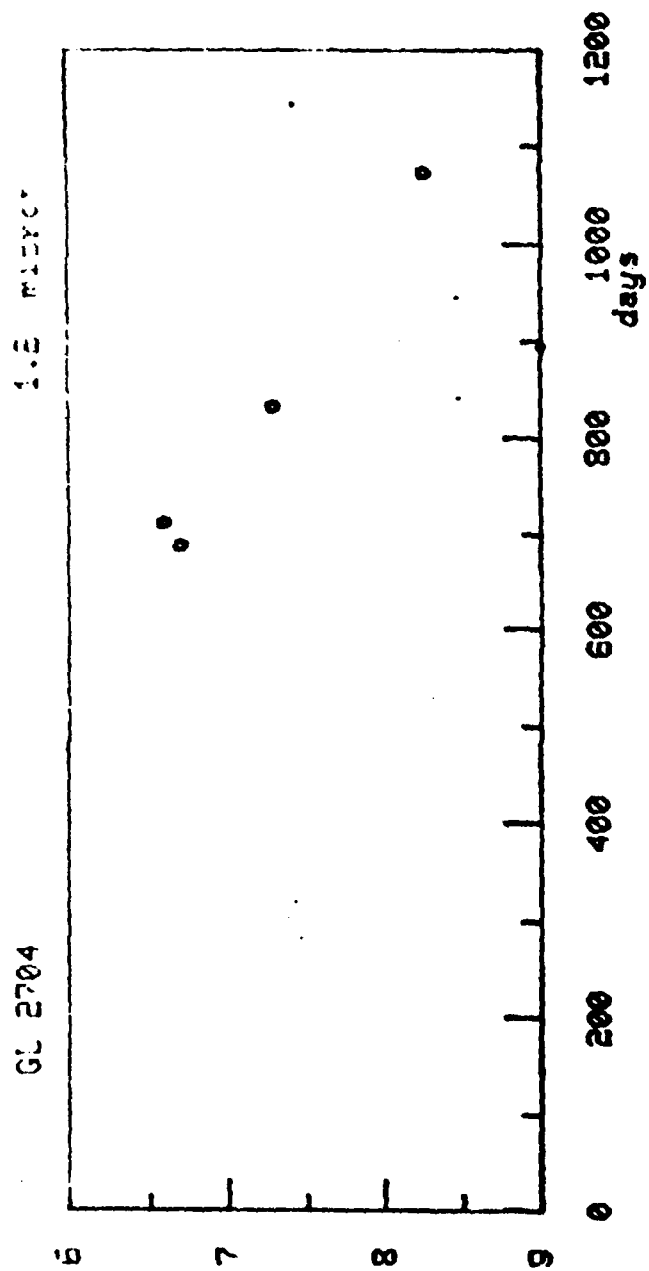


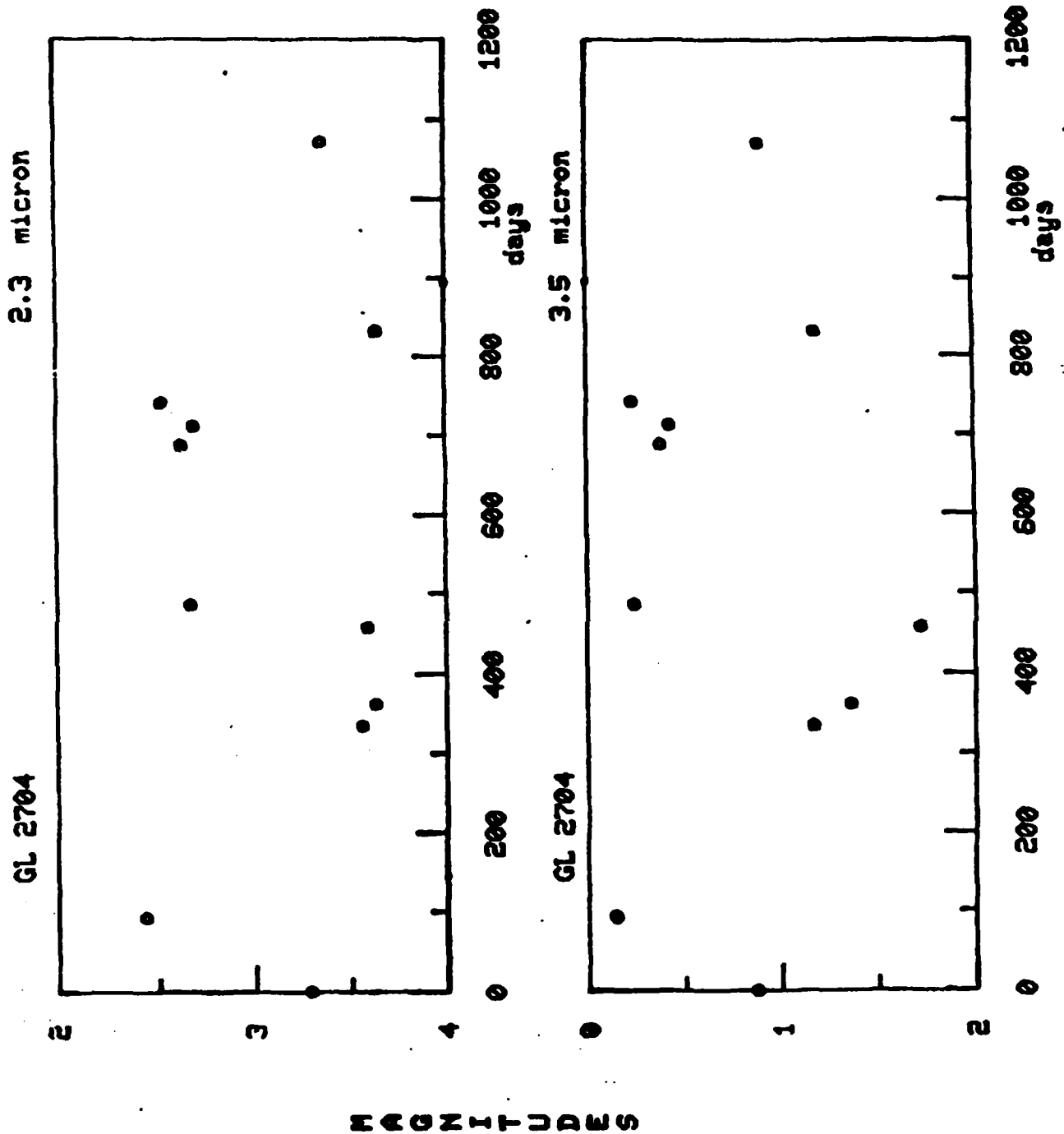


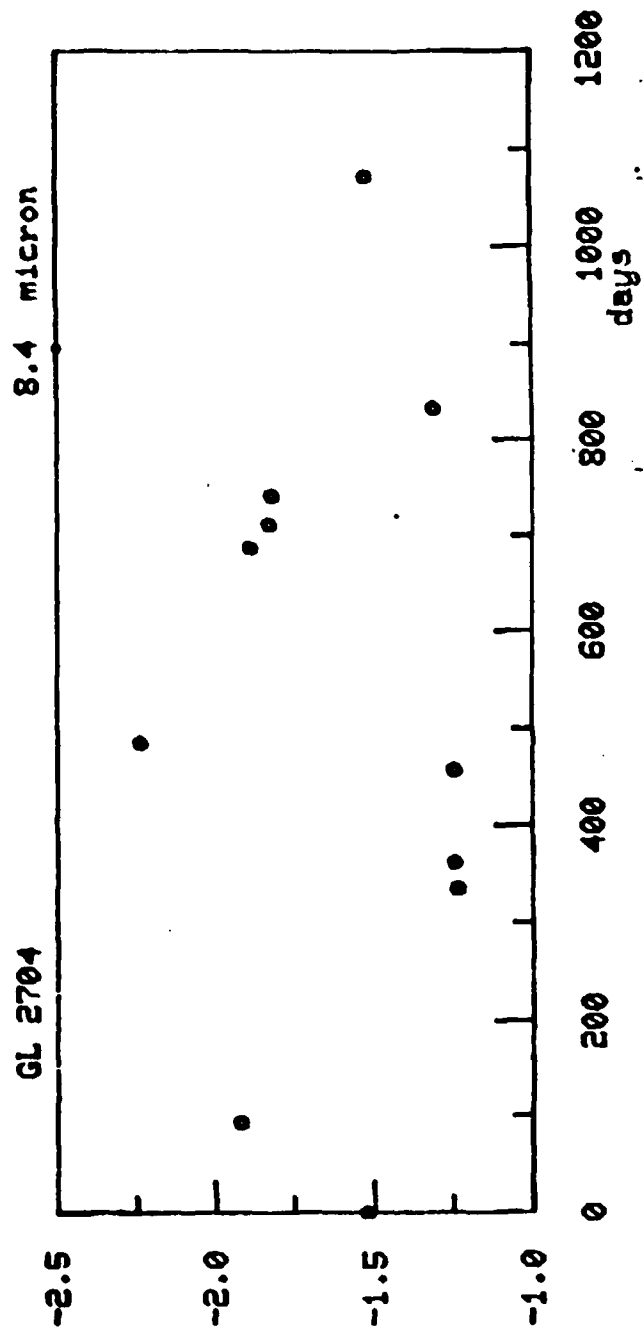
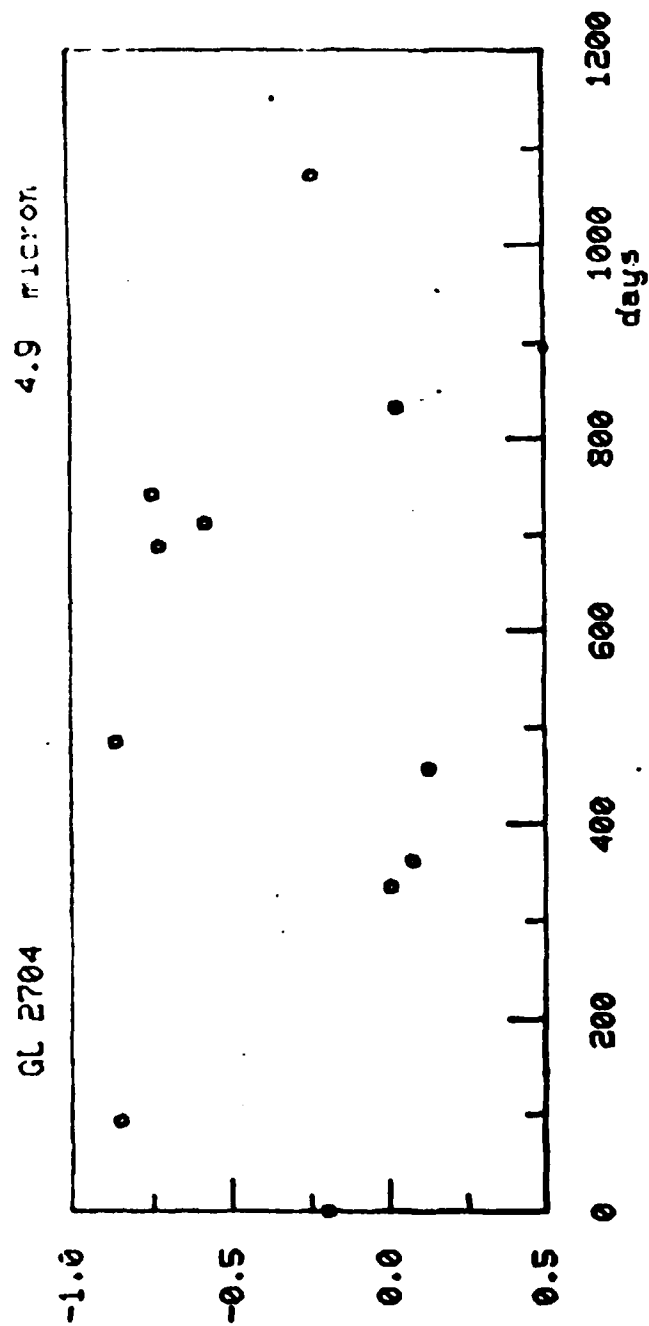


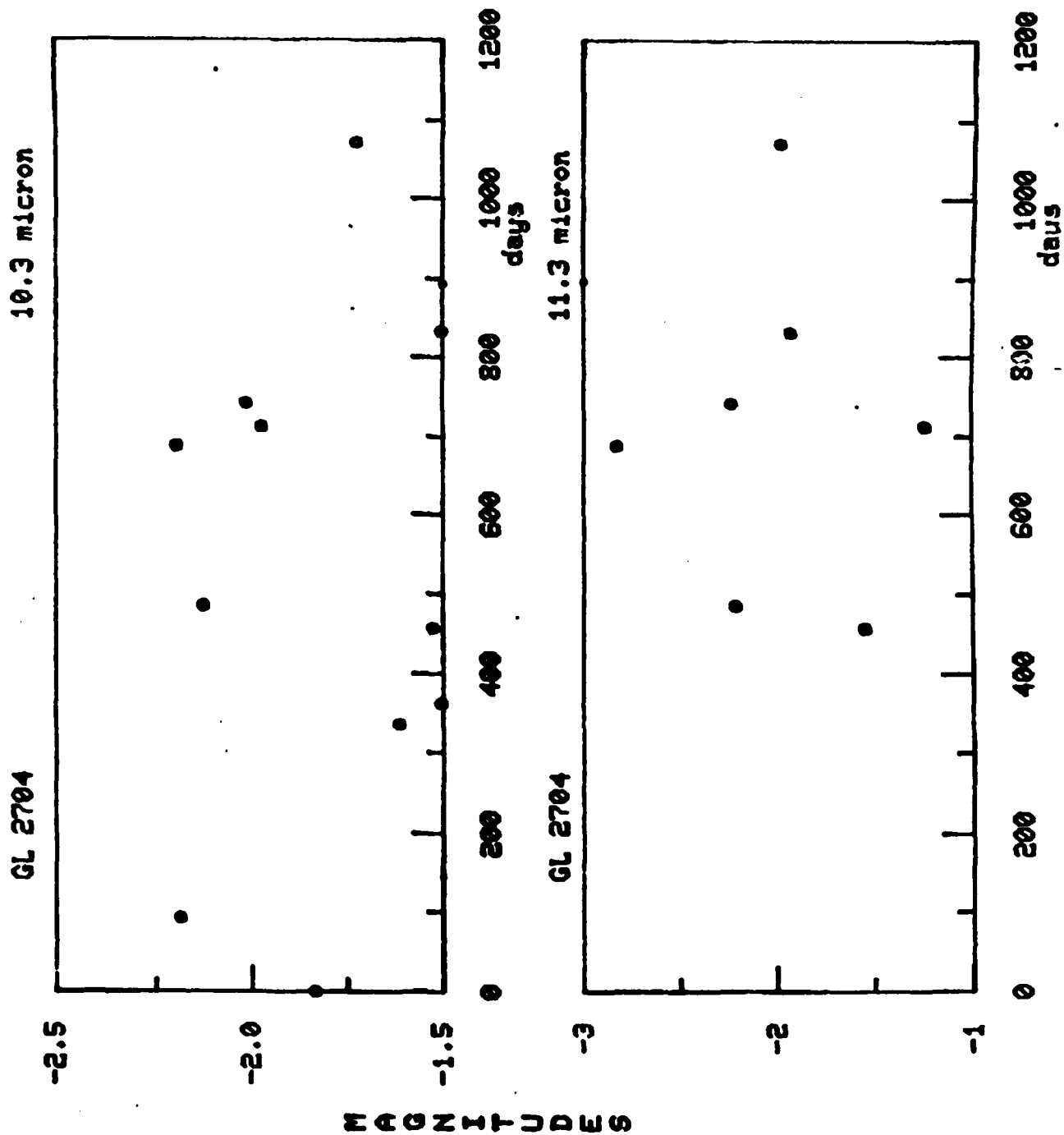


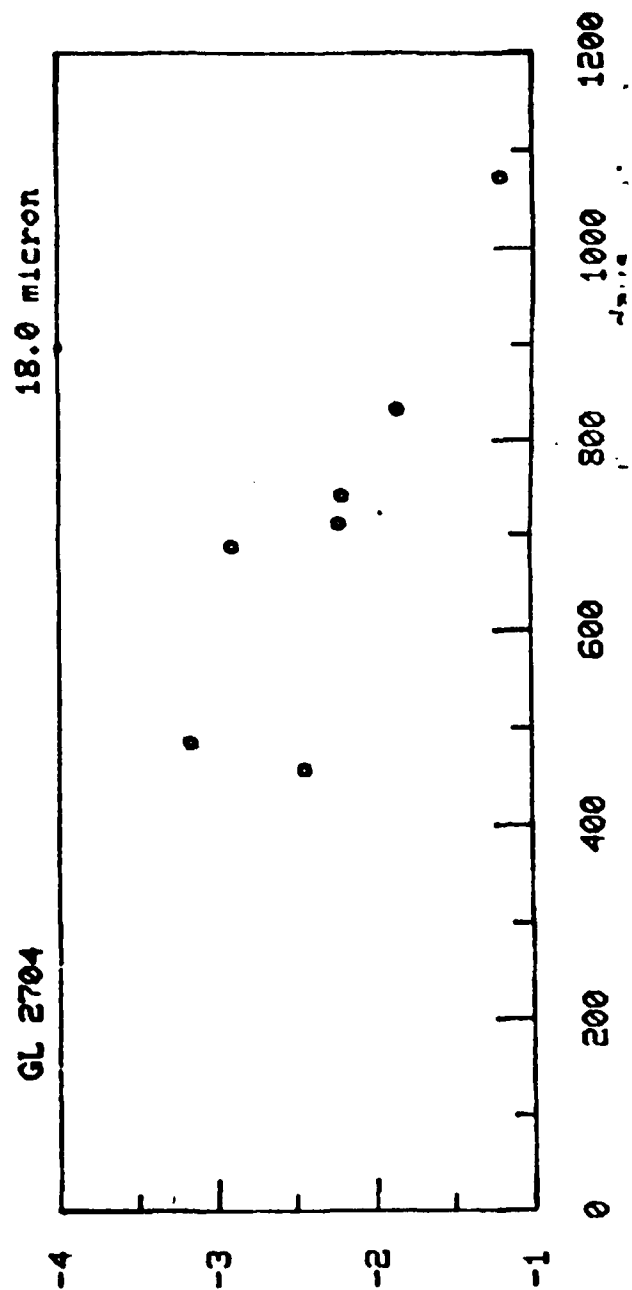
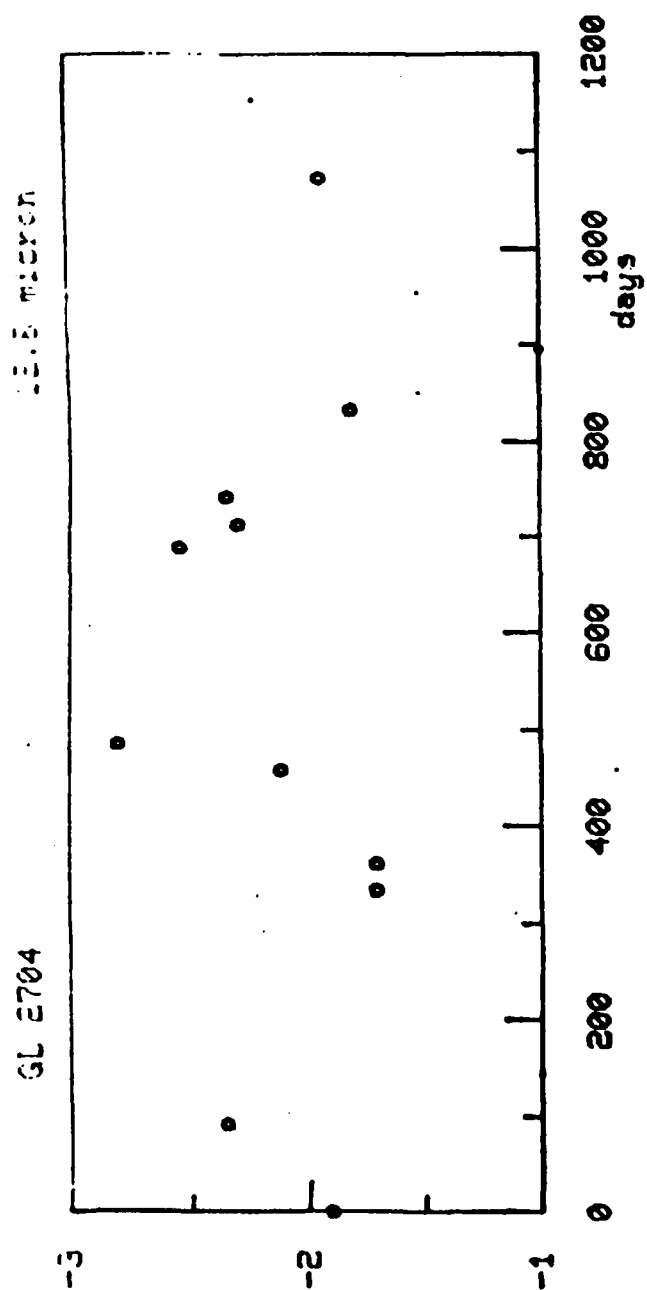


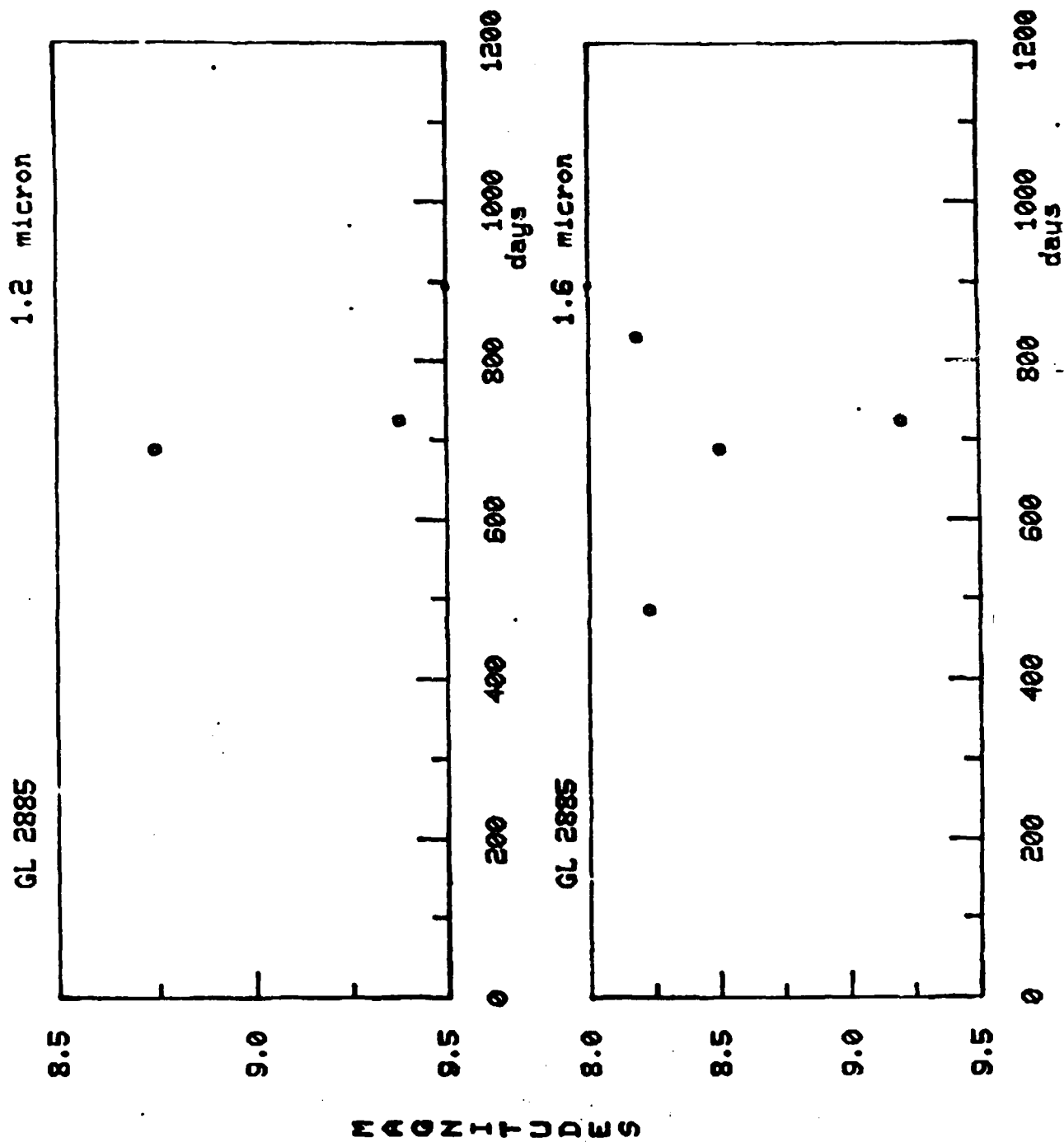


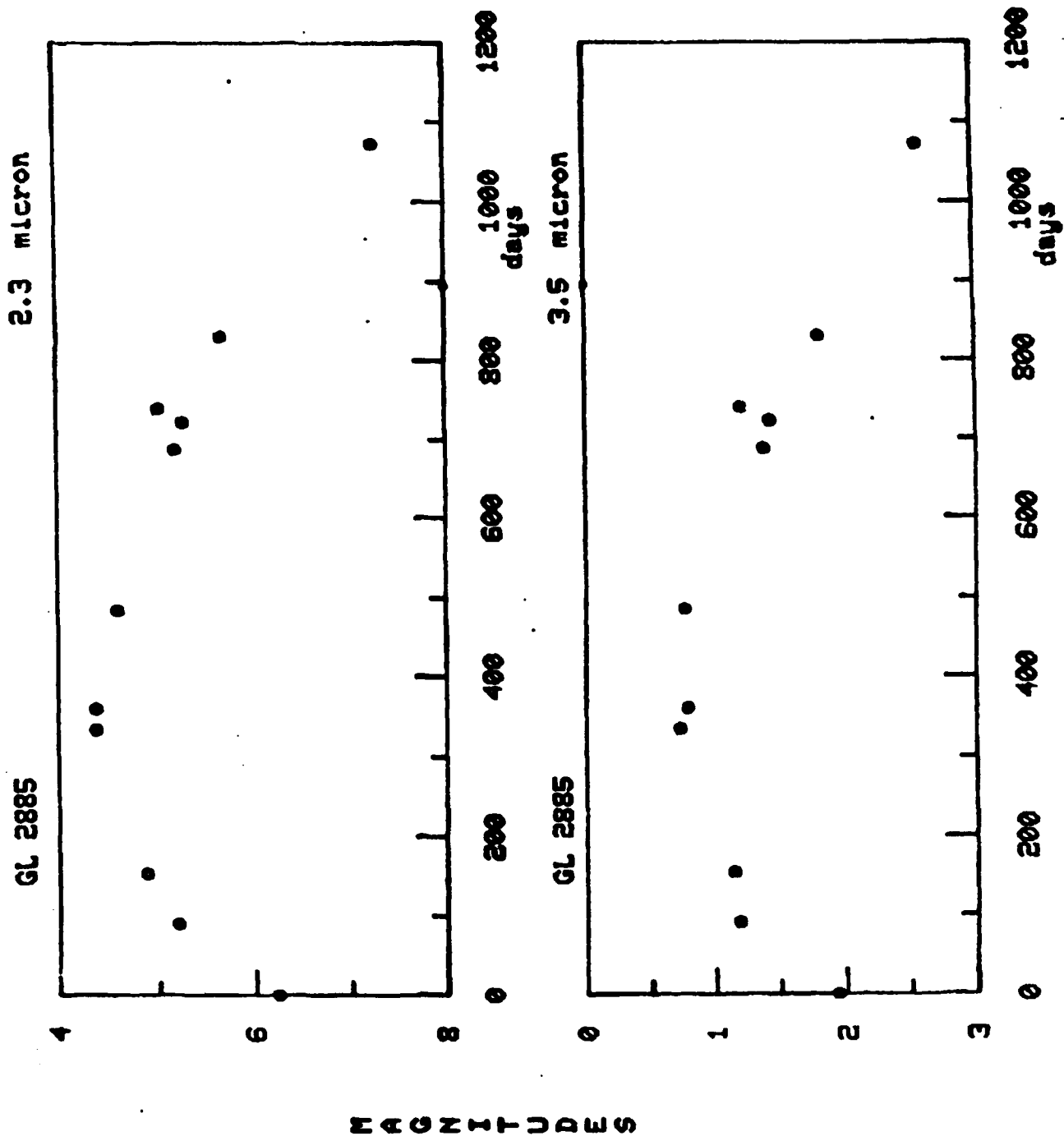


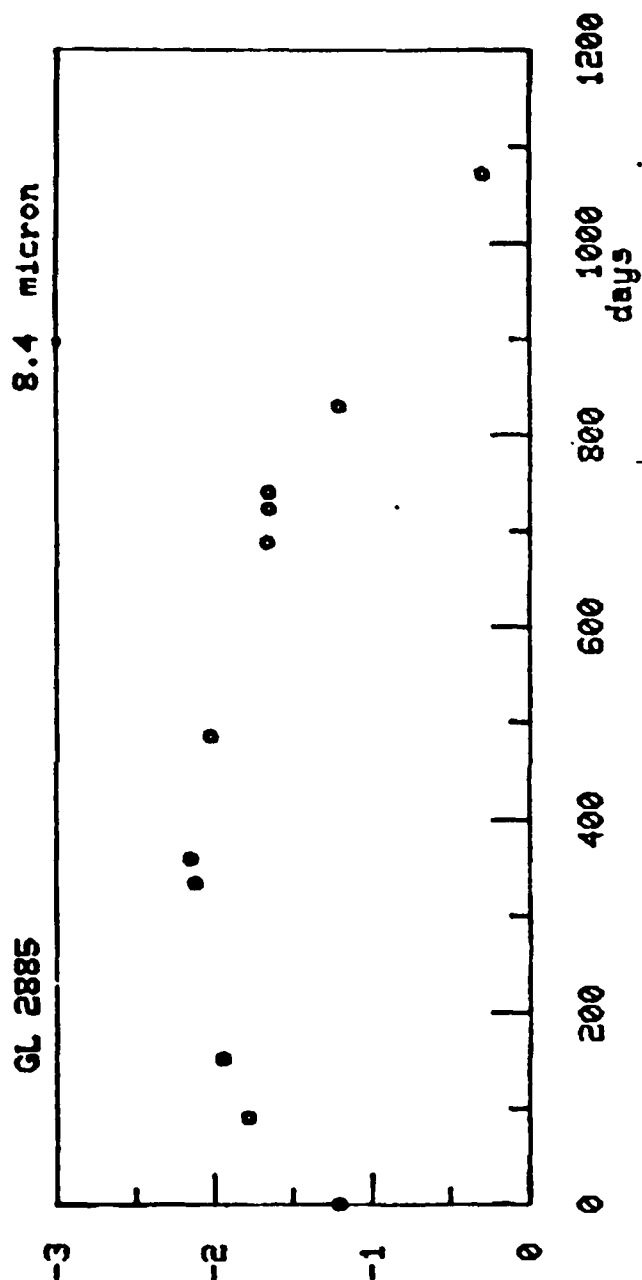
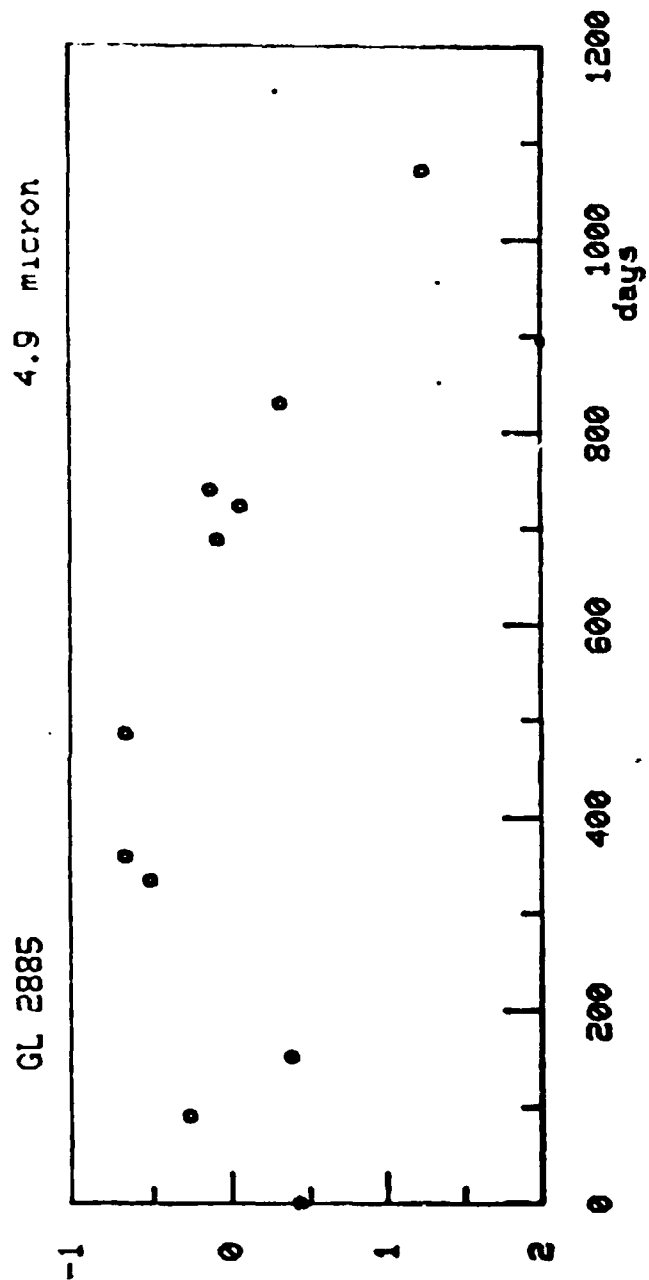






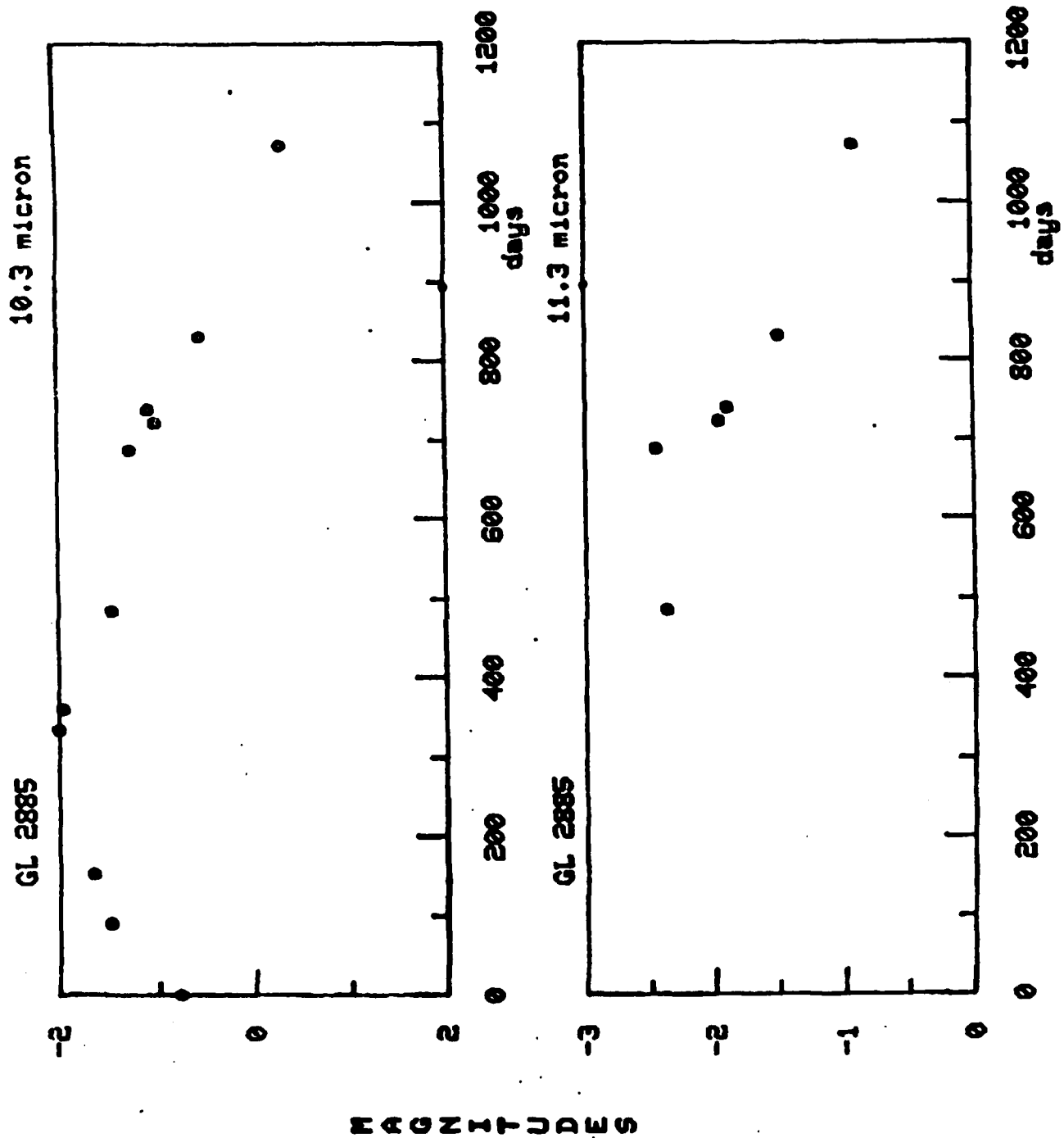


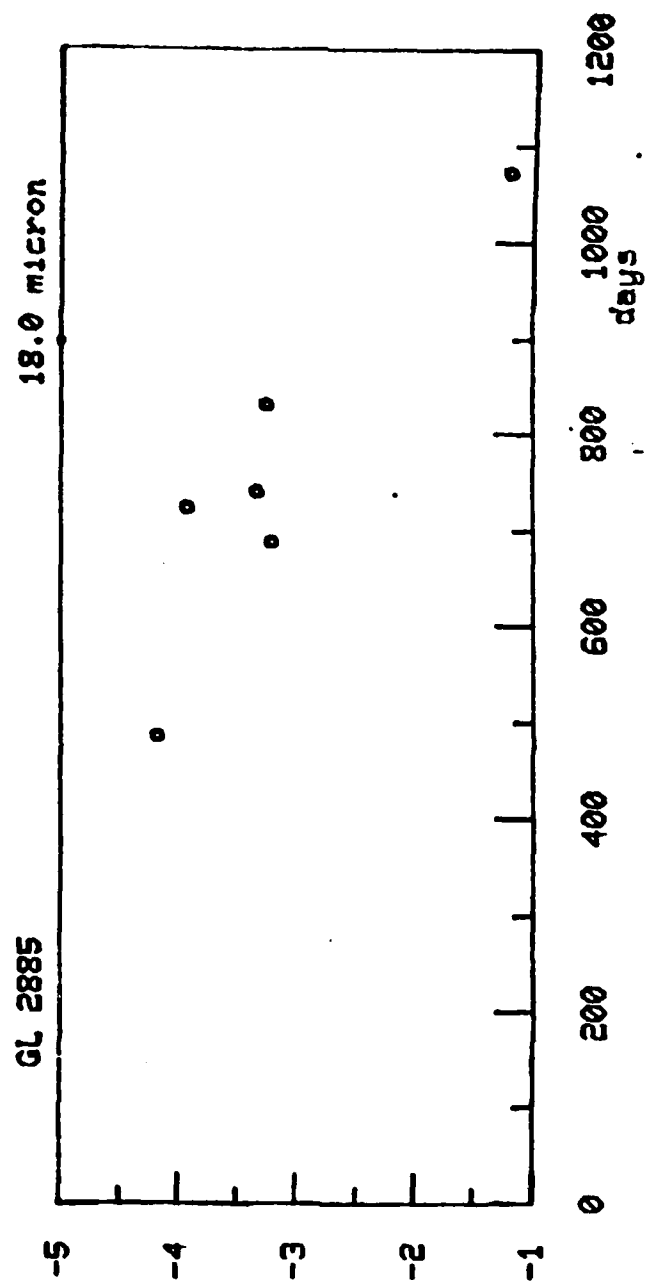
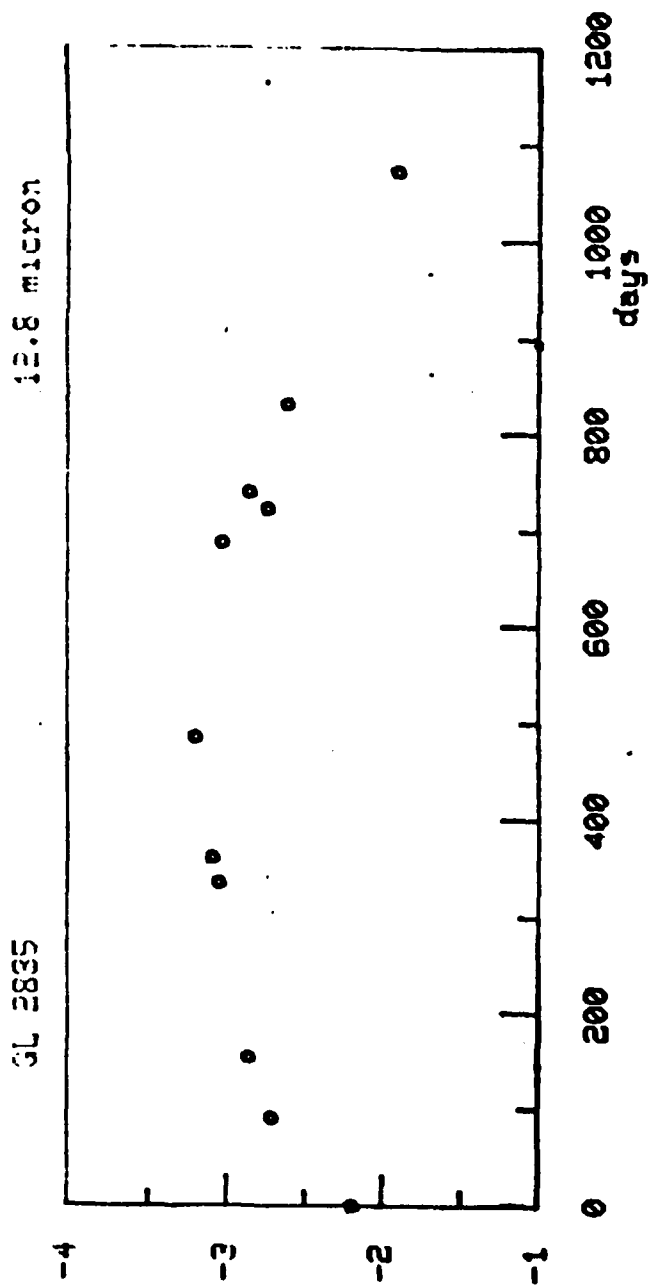




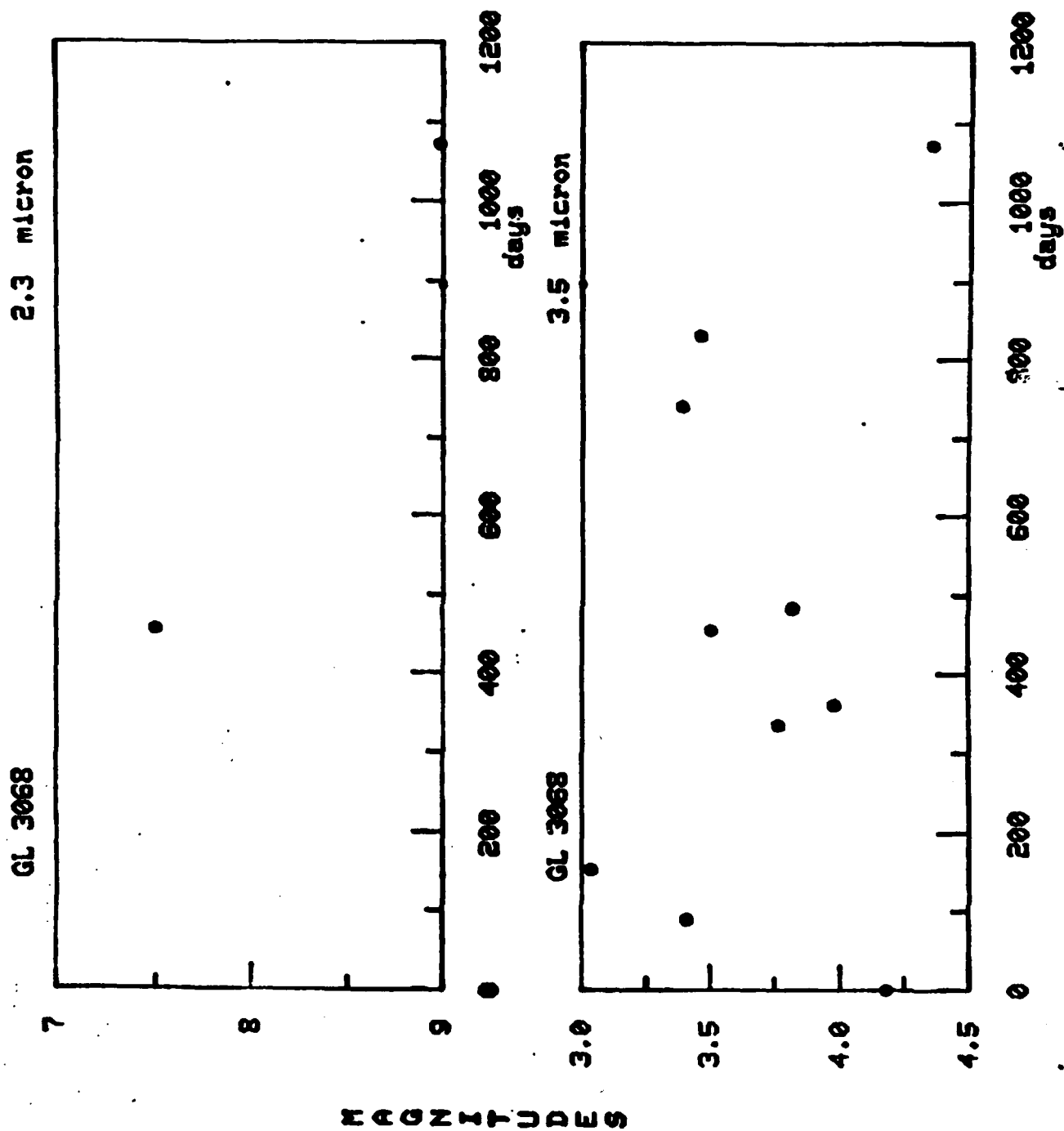
MAGNITUDES

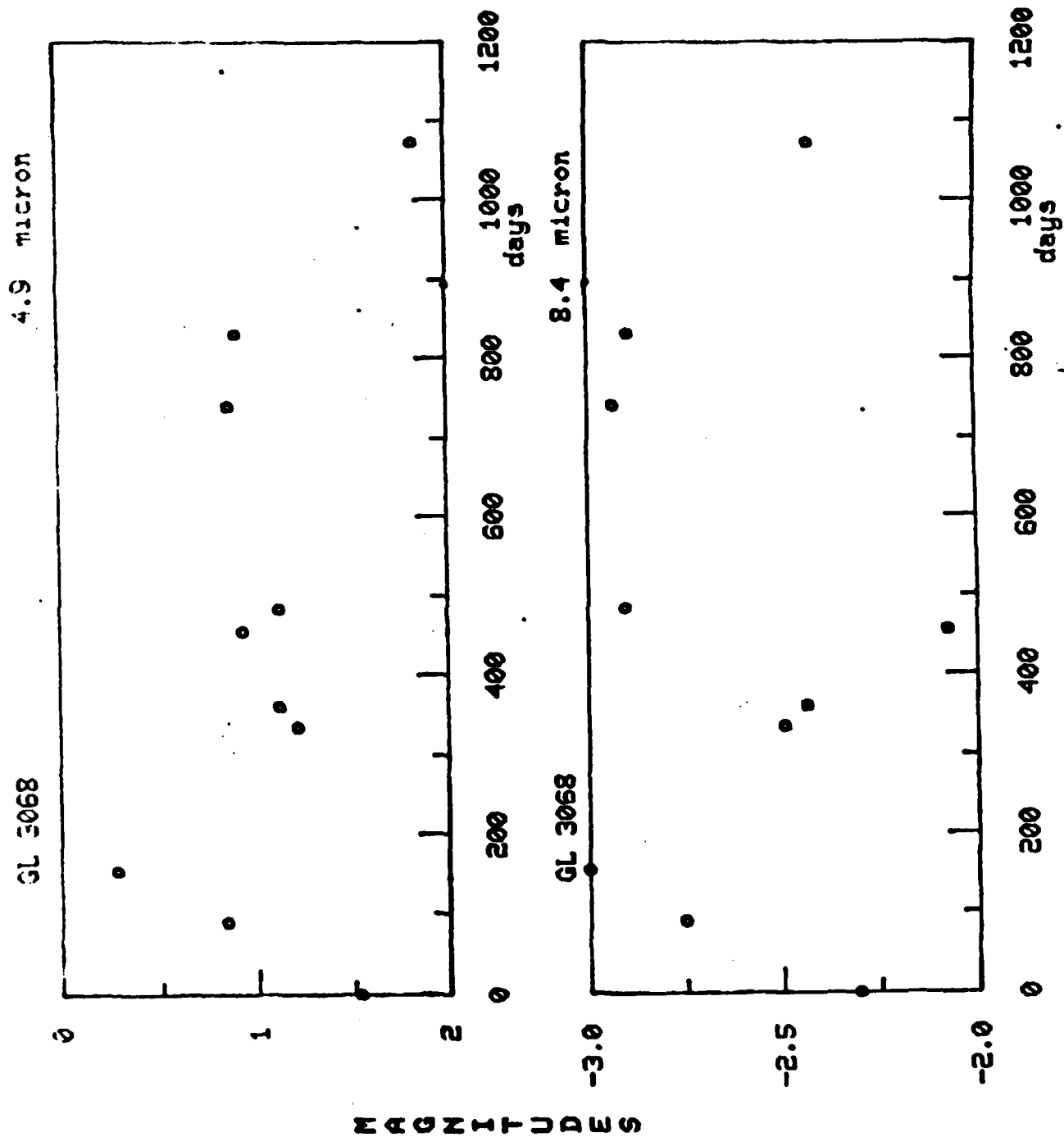


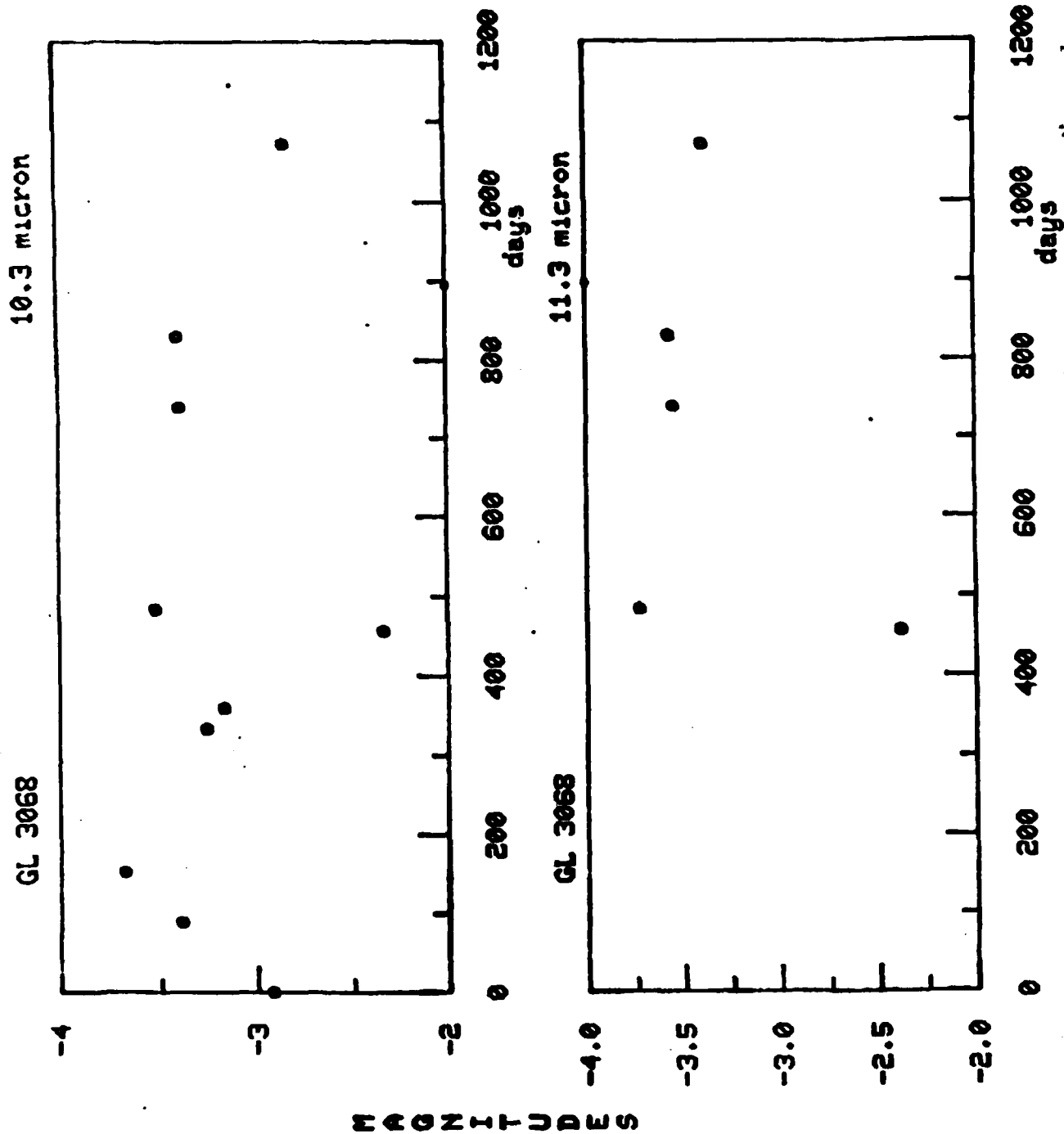




MAGNITUDES







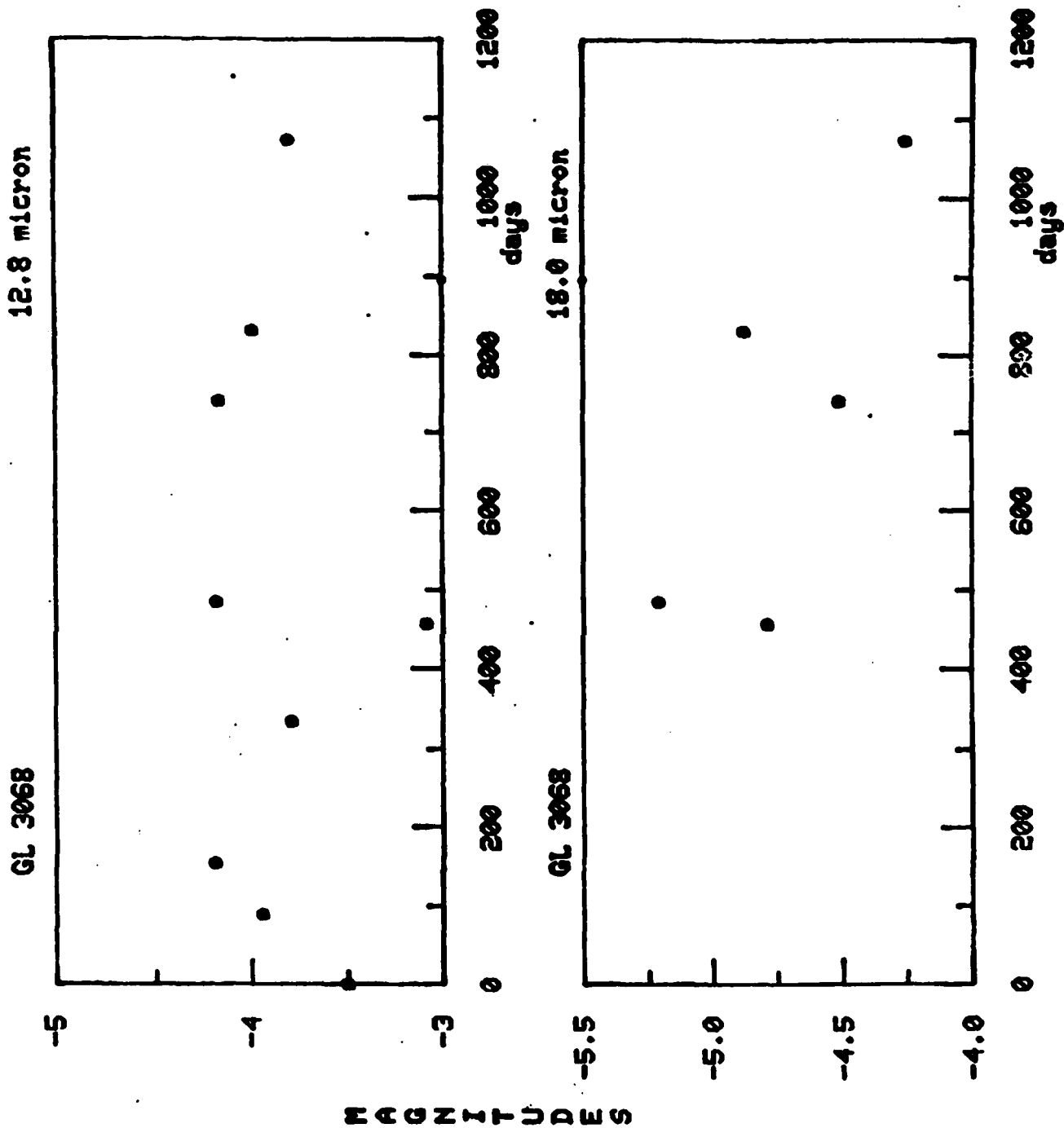
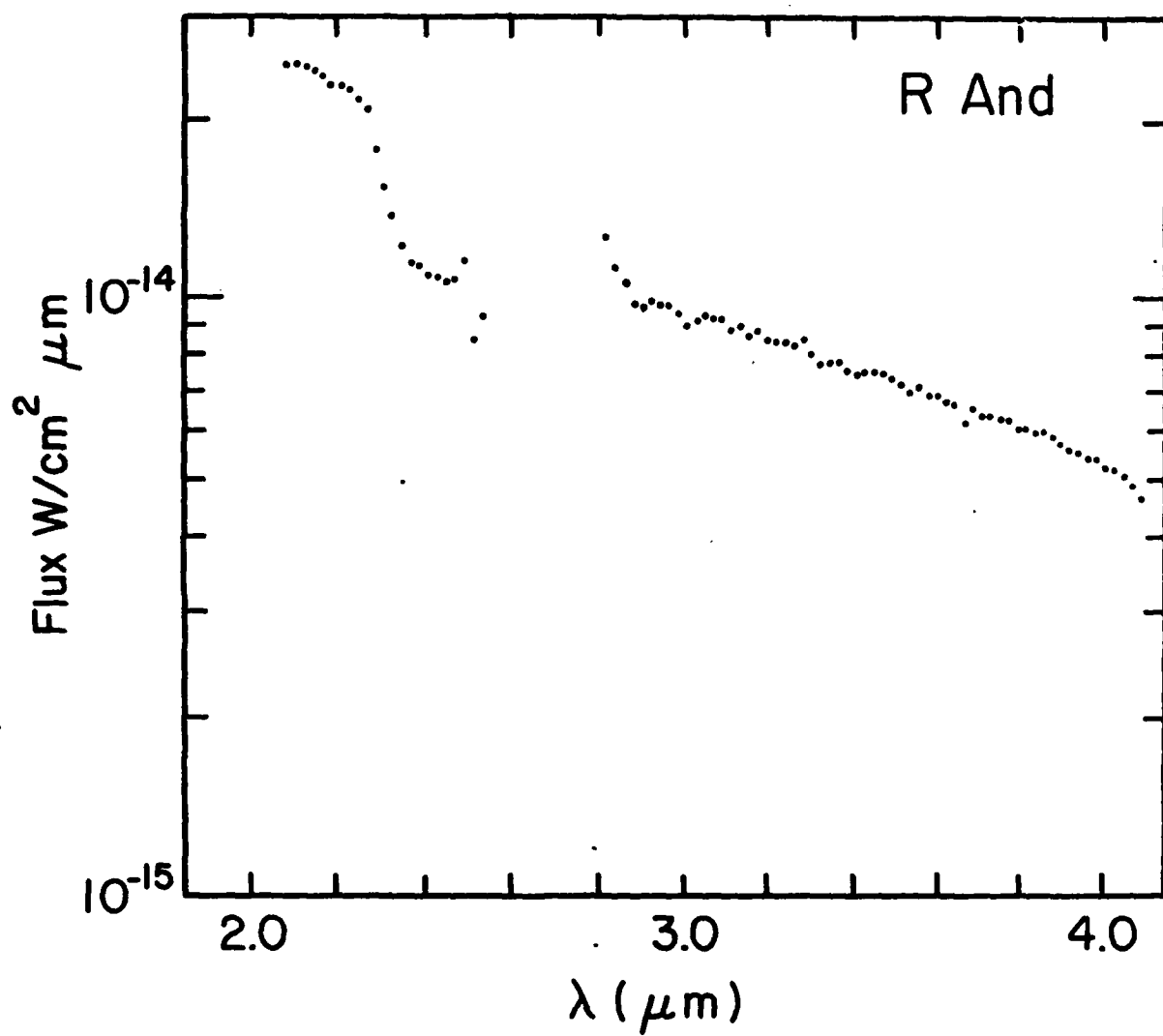
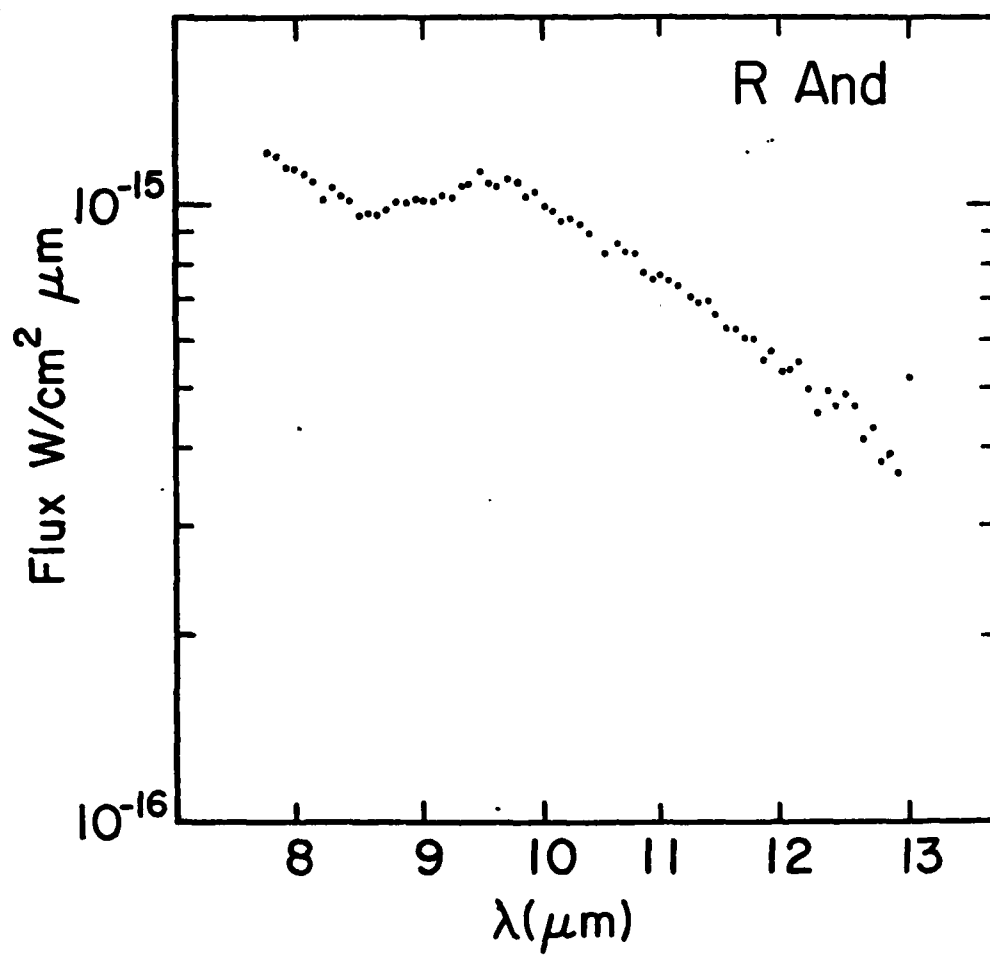
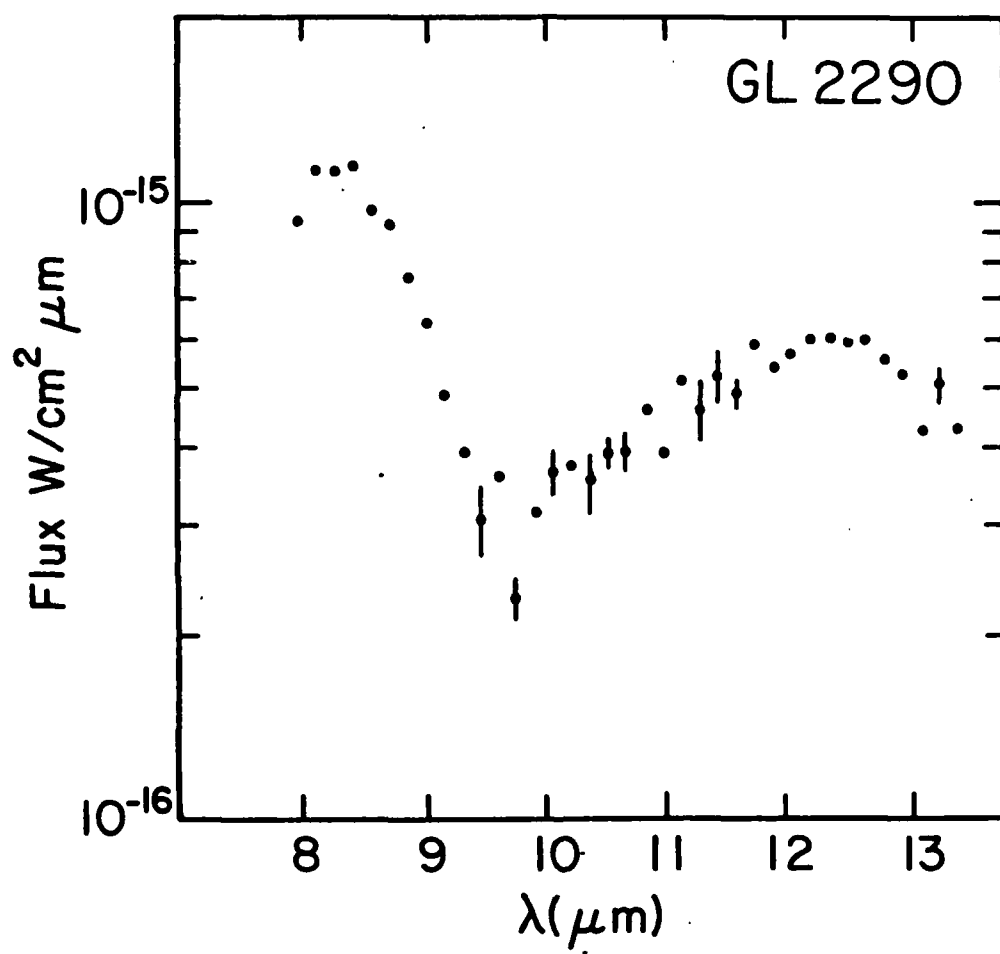


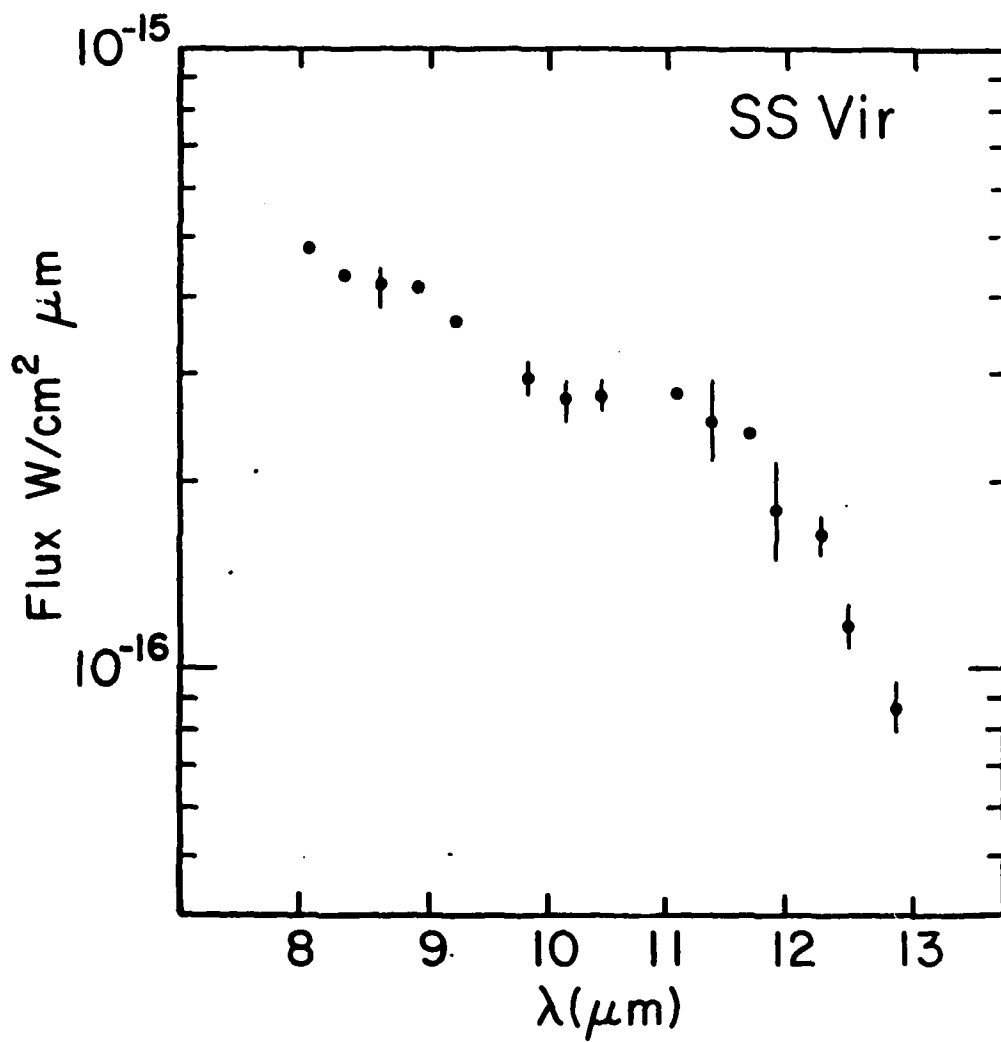
Figure 2











**END**

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